TROPICAL AGRICULTURE

THE OFFICIAL JOURNAL OF THE
IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

VOL. X, No. 6. JUNE, 1933. PRICE 6d.

CONTENTS.

	PAGE.
The New College Course	149
The Soils of Antigua	150
Panama Disease	151
Studies in Tropical Land Tenure	155
Tomato Storage	161
Papaya Cultivation	163
Root Distribution of Sugar-Cane in different Soils in Trinidad	164
Plant Disease and Environment in Southern Rhodesia	172
Top Working old Coffee Trees	177
Reviews	178
Chemical Notes	179
Trend of the Markets	180

THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

Cables :: "Stomata." | Phone :: 2183.

TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, 14, Trinity Square, London, E.C. 3, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

THE NEW COLLEGE COURSE.*

QUITE recently the Governing Body has approved a scheme by which additional training facilities in the form of a new course will be offered next session at the College. This decision has been reached after careful consideration of the experience gained during the past ten years in the teaching of the existing Diploma course. Although the standard of training aimed at and achieved by this course has been high, recent evidence has suggested that the existing entrance qualifications have tended to debar a number of West Indian candidates from the benefits of an agricultural education at the College. Although the present Diploma course has served a useful purpose by producing men who are now filling important posts in the Colonial Agricultural Service and in other spheres of agricultural work, it is felt that, relative to the needs of a certain class of student, it has been, perhaps, somewhat academic in character. In view of this, the College authorities have decided not only to retain this course in a modified form so that the demands of Government and other services for which it specially caters may continue to be met, but also, to offer, in addition, a new course which it is anticipated will meet other needs in the Caribbean area. In this way it is believed that what appears at present to be a gap in the College curriculum will be filled.

The new course, which will be known as the Two-year Certificate course, has been primarily designed for planters' sons and it is hoped also that it will attract others generally interested in the practical aspects of tropical agriculture. Men trained under this scheme will not be eligible for posts in the Government Service.

The entrance qualifications specify that the candidate must be seventeen years of age and possess a Cambridge Lower Certificate or its equivalent with a pass in experimental science or in one of the following subjects:—chemistry, physics and botany. The Certificate will be awarded subject to the candidate's work and general conduct during his two years' period of training and to his having passed certain examinations.

Essentially the course will be a practical one, its main object being to impart practical knowledge regarding improved methods and their application

* Forms of application to this course may be obtained from the Registrar, Imperial College of Tropical Agriculture, Trinidad, B.W.I.

to the cultivation and management of estates. It has been arranged that the Diploma candidates will take the same course during the first two years as the Certificate candidates. During their third year, however, the former will attend classes designed to provide the scientific basis for the practical operations learnt in the first two years. The entrance qualification of the Diploma candidates has, moreover, been raised to that of a Cambridge School Certificate or its equivalent with a *credit* in general science or in one of the following subjects:—chemistry, physics, botany, biology.

The main subjects to be taught to the Certificate students will include crop and animal husbandry; elementary botany with practical instruction in vegetative propagation, and the botany of West Indian crops; agricultural geology, the chemistry and physics of soils and manures and elementary chemistry of plants and animals; practical economic entomology; veterinary science; economic history and geography and agricultural cost accounts and elementary mycology. In addition, a special course of lectures in sugar technology with five weeks' practical work in the Sugar Factory and a short course in agricultural engineering will be included during the second year. The syllabus is comprehensive and has been framed to provide a sound training in tropical agriculture. In spite of the difficult times, it is hoped, that the course will prove an attraction and a help to those members of the younger generation whose interests lie in tropical agriculture.

THE SOILS OF ANTIGUA.

A report* on an account of a reconnaissance survey of the Sugar-Cane Soils of Antigua, B.W.I., by F. Hardy, J. A. McDonald and G. Rodriguez, has recently been published (April, 1933), forming Part V of Studies in West Indian Soils.

The method employed in this work consisted of a full study of typical profiles exposed in pits dug within areas representative of the various soil-types that occur with the area. In all, 36 profiles were examined and sampled, and, in addition, 17 special auger borings were sampled, yielding altogether, 423 soil samples. The following determinations were made:—(1) Index of Texture; (2) Reaction (pH value); (3) Organic Matter Content; (4) Nitrogen Content; (5) Carbon Nitrogen Ratio; (6) Calcium Carbonate Content; (7) Total Soluble Salt Content; (8) Sodium Chloride Content; (9) Available Phosphate Content, and (10) Available Potash Content.

The report may be broadly divided into three parts, namely, (I) A general description of the topography, geology, climate and chief methods of cultivation in Antigua. (II) The classification of the Antigua sugar-cane soils, and a description of their chief characteristics and agricultural relationships, based on the laboratory data and field evidence. This part includes a discussion on the classification and chief features of Saline and Alkaline soils. (III) Laboratory data and brief descriptive notes for all the soil samples, presented in tabular form, comprise an appendix to the report. A rough soil map of Antigua is also presented; its construction was based on the field notes, laboratory data and special observations of road-side sections and rock exposures.

The chief findings of the investigation are as follows:—

(1) The sugar-cane soils of Antigua may be broadly classified into (A) Non-Calcareous Soils, and (B) Calcareous Soils. Each of these classes may be subdivided into (*a*) Non-Saline Soils and (*b*) Saline Soils. These four sub-divisions correspond to recognised pedological groups.

(2) The *non-calcareous soils* of Antigua are derived mainly from sedimentary tuffs and river alluvium; they occur respectively in the Central Plain area, and in the South-Western Volcanic area. The *calcareous soils* are derived chiefly from limestones and marls which occur in the northern and eastern areas, and also from the calcareous facies of the sedimentary tuffs. The saline, calcareous ("black alkali") soils are derived mainly from siliceous limestone that out-crops sporadically within the North-Eastern part of the limestone and marl district.

(3) The most fertile soils are the calcareous, non-saline, Limestone, and Marl Soils; the calcareous, non-saline Sedimentary Tuff Soils are almost as fertile, but the non-calcareous non-saline Sedimentary Tuff Soils exhibit varying fertility. The saline representatives of the Sedimentary Tuffs ("white alkali" soils) generally show low fertility. The saline calcareous soils ("black alkali" soils) are quite infertile, they occur as isolated "gall patch" areas of varying extent.

(4) The most striking general features of the Antigua sugar-cane soils are, (1) their high degree of alkalinity, (2) the frequent presence in them of notable amounts of common salt, (3) the presence of variable amounts of calcium carbonate, which in some cases dominates the soil system, and impresses thereon characteristic physical and chemical properties.

(5) The permeability of the soils varies widely. In some instances, subsoil accumulations of gelatinous Bentonite entirely prevent downward percolation.

(6) The nutrient status of the soils is generally unsatisfactory, owing to the high degree of alkalinity, or to the presence of excessive amounts of calcium carbonate. Available phosphate particularly appears to be lacking.

(7) Recommendations for the amelioration of the less fertile sugar-cane soils of Antigua are given.

* To be obtained (price 1/-) on application to the Editor, *Tropical Agriculture*, Imperial College of Tropical Agriculture, Trinidad, B.W.I.

PANAMA DISEASE.

A Review of the Occurrence of Panama Disease on the Cavendish or Dwarf Banana in the Canary Islands.

By C. W. Wardlaw.

A highly important aspect of banana cultivation is that of susceptibility to Panama or Wilt Disease, the Gros Michel, the chief variety of commerce being particularly subject to infection. For many years the Dwarf, Cavendish*, Chinese or Canary variety (*Musa cavendishii*), second only to the Gros Michel in commercial importance, was regarded as immune to *Fusarium oxysporum cubense*†, the causative agent of Panama Disease. During recent years, however, a wilt disease of increasing importance has made its appearance on this variety in the Canary Islands. In Trinidad and in other West Indian Islands, on the other hand, where Panama Disease is widespread, the Cavendish or Governor variety appears to enjoy what is practically complete immunity. Thus, although suckers have been planted in areas and even in the exact sites where the Gros Michel has consistently succumbed, infections culminating in unmistakable Panama Disease have not been recorded. Taking these several facts into consideration it is now more accurate to refer to this variety as being highly resistant.

The principal varieties in the Caribbean susceptible to Panama Disease are the Chamaluco in Porto Rico, the Manzana in Cuba, the Gros Michel in all the chief banana-growing areas with the exception of the Santa Marta district in Colombia, and the Red banana in Panama and Costa Rica. Brandes‡ records the suggestion advanced by one or two investigators and a number of planters that other varieties including the Dwarf or Cavendish may also be attacked. "Dr. J. R. Johnston, Plant Pathologist of the Cuban Experiment Station at Santiago de las Vegas, reports having seen affected dwarf bananas in Panama in 1912, and to have isolated a species of *Fusarium* from affected tissues. I was unable to verify this in 1927, although scores of suspected plants were examined in the same region. However, there is no reason for doubting that this species may be affected under suitable conditions."

It seems probable that the several cases of Wilt Disease of the Dwarf variety observed in the Caribbean region were due to the Moko or Bacterial Wilt Disease (*B. solanacearum*) which is now known to be widely distributed.

* In Trinidad the Dwarf or Cavendish variety is generally known as the "Governor".

† The trinomial *Fusarium oxysporum cubense* is now being used to denote the fungal organism formerly referred to as *F. cubense*.

‡ Brandes, E. W.—Banana Wilt. *Phytopath*, IX, No. 9, 1919, pp. 343-344.

Early Evidence of the Disease in Teneriffe.

It is little more than eight years since Panama Disease was first reported in the Canary Islands.* From material sent to the Imperial Mycological Institute in 1924 a typical strain of *F. cubense*, similar to that obtained from infected Gros Michel suckers in the West Indies, was isolated. In 1926 the following commentary appeared in the columns of this Journal†. "The Cavendish banana is regarded in the West Indian region as either very highly resistant or immune to the disease. In Jamaica, for instance, it has not been found to be attacked and is considered there to be immune. In Central America it has been reported to be occasionally affected by a wilt resembling Panama Disease and a *Fusarium* has been found in the vascular system which differs somewhat in culture from *Fusarium cubense*, the recognised cause of the disease on susceptible varieties in the West Indian region. About 15 years ago when Gros Michel was attacked by Panama Disease at the St. Augustine Experimental Station in Trinidad, the Chinese banana was substituted for it and developed a disease when supplied to infected spots which the then Superintendent believed was the same disease as that on the Gros Michel. The Mycologist, however, did not record the disease as attacking the Chinese banana. It may be added that the *Fusarium* isolated from the vascular system of affected Cavendish bananas in the Canaries behaves in culture like *Fusarium cubense* of the West Indies. Dr. Butler has suggested, therefore, that the *Fusarium* in the Canaries may be a different biological strain from that in the West Indies. As the strain or strains of the fungus present in the West Indies, rarely, if ever, attack the Chinese banana there, it is highly undesirable that the strain in the Canaries should be introduced into the West Indian region where the Chinese banana is widely cultivated by the peasantry and might become in the near future acceptable for export to northern markets. It would be prudent to forbid the introduction of banana suckers from the Canaries into any British West Indian territory except for experimental purposes and then only if they have been taken from plants grown in quarantine and are certified by a competent authority free from Panama Disease."

Recent Investigations.

Although it has been known for some time that the new disease in the Canary Islands was on the increase, definite published information has been

* According to some observers Wilt Disease was in evidence as early as 1921.

† (S.F.A.)—Panama Disease of Bananas in the Canaries and West Africa. *Trop. Agriculture*, III, 1926, p. 8.

lacking. A Memoir on this subject recently issued by the Estacion Central De Fitopatologia Agricola, Madrid, based on the investigations of Messrs. J. Del Canizo and J. Rodriguez Sardina*, is therefore particularly welcome. The remainder of the present article is based on the information submitted in their Report.

According to these authors, diseased material from the Orotava Valley, Teneriffe, was sent to Madrid in September, 1925, for examination. The infected plants showed putrified roots with abundant fungal mycelium and sometimes Nematodes. In 1926 a preliminary Report was issued in which various remedial and control measures were suggested including liming of the soil, modification of the manurial formulae generally used, localisation and treatment of infected areas, &c. In 1928 the authors isolated, from a diseased banana trunk, a fungus of the genus *Fusarium* (*Section Martiella*). The disease, which appeared to decrease in 1927 and 1928, years of low rainfall, reappeared with alarming intensity in 1929 and 1930, and many plants were destroyed. As a result a scientific investigation was requested by the planting community.

Symptoms.

Affected plants show symptoms closely comparable with those observed in the Gros Michel, namely, wilting accompanied by yellowing of the leaves, which commences as a marginal drying out. These symptoms are apparent first on the lower or outermost leaves and later in the younger or inner leaves, the change from the normal green to yellow being sudden. Such pathological effects are quite different to those resulting from water shortage. Once the leaves are affected they wilt more or less rapidly and usually break at the petiole, thereafter hanging down and drying out. The inner leaves, which last longest, finally succumb and the plant dies. The disease is most evident at the onset of fruiting. Sound bunches are rarely obtained from affected plants, the fruit being abnormally small, yellow and of poor flavour. When trunks or bulbs are cut open, characteristic discolourations of the vascular strands, from yellow to dark brown, are easily observed and the presence of fungal mycelium in them may also be demonstrated. Although instances were not actually observed by them, the authors state that the longitudinal splitting of the base of the pseudo-stem or trunk, usually observed in Wilt Disease of the Gros Michel, may also take place.

Isolation of the Fungus.

It has already been mentioned that as early as 1924 cultures of *F. cubense* had been isolated at the Imperial Mycological Institute. From infected trunks Messrs. Del Canizo and Rodriguez Sardina isolated two strains of *Fusarium*. On being submitted to Dr. Wollenweber one of these was identified as *Fusarium oxysporum* Schl. f. 3 Wr.* which is synonymous with *F. cubense* E. F. Sm., and the other as *F. oxysporum* Schl. f. 4 Wr., which is synonymous with *F. cubense* E. F. Sm. var *inodoratum* Brandes—both being morphological forms previously isolated from Caribbean specimens of Panama Disease on other varieties.

Mode of Infection.

Infection may take place through the bulbs or heads ("cabezas") or the roots. In this section the authors refer at some length to the work of the present writer† in which various external soil factors, such as inadequate aeration and variable moisture supply, were shown to be important in promoting root infection: on the other hand, under favourable conditions, the inner tissues of injured suckers and roots are protected against fungal penetration by the rapid development of suberised cambiform barriers.

Ecological and Agricultural Conditions.

In the Memoir under consideration the authors have gone into the questions of climate, soils, application of fertilisers, irrigation and general cultural practices relative to the incidence of Wilt Disease. As these aspects of banana cultivation in the Canary Islands have already been described in detail by Holmes‡ in this Journal, only a brief reference to some of the more salient features need be made.

Banana cultivation is confined to the lower coastal region up to 350 metres altitude. The mean annual temperature is 21° C., the minimum does not go below 11°C., while the maximum under shade does not exceed 38° C. The most outstanding feature of the climate is the very small range in temperature at a given altitude. At sea level the mean annual change is only from 6° to 8° C.; the mean winter temperature is 16° to 17° C.; the temperature during August is between 18° to 19°C. The persistent high temperatures during autumn are regarded as important. All rainfall is in winter from November till March, very dry weather being the rule during June, July and August. The total annual rainfall is 300 mm. (12 inches). The cloudiness is considerable and serves to temper the heat of the sun.

Although the disease is undoubtedly accentuated by adverse soil conditions, even on good soil and under good cultivation a few cases of wilt may be

* J. Del Canizo and J. Rodriguez Sardina. La Enfermedad de la Platanera en el Valle de la Orotava. *Boletin de Patologia Vegetal y Entomologia Agricola*, Madrid, VI, 1933.

* For the recently revised nomenclature of species, varieties and strains in this Section of *Fusarium*, readers are referred to Wollenweber's Fusarium-Monographie. *Zeit. f. Parasitenkunde*, III, 3, 1931.

† Wardlaw, C. W.—The Biology of Banana Wilt (Panama Disease). *Annals of Botany*, XLIV, 1930; XLV, 1931; *Trop. Agriculture*, VII, 10, pp. 278-281, 1930.

‡ Holmes, E. — The Canary Banana. *Trop. Agriculture*, VII, 12, pp. 320-325, 1930.

found. The authors point out, however, that during the last few years plantations have been established on soils very little suited to the banana because of their shallowness (*e.g.*, 12 inches of soil above an impermeable subsoil). In one estate where such conditions prevail, the plants had to be destroyed one year after planting. The slope of the land and the scarcity of soil necessitate banking and the formation of artificial terraces so that the depth of soil may vary from 18 to about 40 inches. Furthermore, it has been recognised that there is considerable variation in the nature of the soil from valley to valley and even from terrace to terrace. As a rule the soils are poor in organic matter and lime.

In Orotava, irrigation is carried out every 12 to 15 days, at the rate of 650 cubic metres per hectare (2½ acres approximately), *i.e.*, about 20 irrigations are carried out each year.

Spread of the Disease.

The infection may be transmitted directly from parent to daughter suckers. The spread of the disease from one place to another may be due to the use of diseased "bits" and suckers, or it may result from failure to destroy infected material, the remains of infected plants when dug out being sometimes thrown to animals or put into manure heaps by the farmers. A further cause of infection is the practice of replanting immediately in the precise sites from which diseased plants have been dug out: in some such instances the infection has been observed to repeat itself three or four times in succession.

Although the symptoms do not become visible until later, the rainy season is undoubtedly the time most favourable to the propagation of the disease. An indication of its progress throughout a year is afforded by the number of plants destroyed each month. The following characteristic quotation refers to one property; all the rain falls between November and March, while the major disease effects are seen from April to July.

	Year	
	1930.	1931.
January	60	48
February	64	63
March	150	80
April	220	182
May	404	323
June	903	665
July	301	Data lacking.
August	158	do.
September	48	do.
October	46	do.
November	46	do.
December	40	do.

As elsewhere, infection may be spread by the use of implements which have been used on diseased plants and not subsequently disinfected. Irrigation water may also serve as a means of disseminating the pathogen.

In Teneriffe the spread of the disease has been favoured, amongst other causes, by the increased area of cultivation. This has meant the utilisation of high lands little suited to the banana. In such areas the insufficiency of irrigation water is very important, while the shallowness of the soils, their extreme poverty in lime, the inadequate use of manures, particularly those supplying nitrogen, and defective methods of cultivation are all important contributory factors.

The authors consider that the resistance which the Cavendish variety possesses by virtue of its genetic constitution* is only relative, as has been shown by the spread of the disease in the Orotava Valley: it is also clearly influenced by those external factors which affect the health of the plant rendering it susceptible to attack. In dealing with this aspect the possibility of more virulent biological races of *F. cubense* having developed in the Canary Islands, as originally suggested by Dr. Butler, must not be overlooked.

Treatment.

As the disease is internal, actual curative treatment cannot be applied. Nevertheless much may be done to check its spread. Since the fungus, a facultative parasite, normally lives in the organic matter in the soil until conditions favourable to parasitic attack present themselves, it is considered that all methods which tend to create conditions adverse to the fungus but favourable to the vigorous growth of the plant, should help to check the spread of the disease and limit its intensity. That this is not a purely theoretical contention has been confirmed by actual facts. In one farm in the Orotava Valley where 5,411 stools had to be destroyed in 1929, only 2,440 became diseased in 1930: in neighbouring farms, on the other hand, the disease was increasing during this period. The good results obtained are attributed to the application of the measures prescribed.

Preventive and remedial measures include the care and manuring of the soil, adequate treatment of infected areas, replanting and cultivation of new plantations. Water-logging of soils, as well as drought conditions, should be avoided: humid areas should be drained and irrigation so regulated that weakening of plants through drought is avoided.

Liming.—As soil acidity considerably influences the development of the pathogen, the deficiency of lime in affected soils should be overcome by applications at the rate of 2,000-2,500 kg. per hectare. It is advised that the quick lime be placed in small heaps of 2-2½ kg. between each four stools and covered with a little earth,

* The possibility of more than one strain of the Cavendish variety being present in the Canaries has been suggested (*see* Holmes *loc. cit*). It would be interesting and directly useful to know if this is so, and if the strains are equally susceptible.

so that it may slowly become slaked. This latter process takes about 20 days, after which the lime may be spread and incorporated into the soil. It is stated that the few farmers who applied lime as recommended in 1926 are unanimous as to the good results obtained.

Manuring.—The soils are characteristically shallow and much manure is required. While the Orotava farmers usually manure heavily, the mixtures applied are regarded as defective, chiefly in respect of the proportions of the different essential elements*. The unbalanced nutrition which results is regarded as undoubtedly favourable to the disease.

From analyses obtained by taking into account the different parts of the plant (stem, leaves, fruit) their proportion by weight, and the normal crop produced, the average relation between phosphorus and nitrogen, and between phosphorus and potassium necessary to the banana can be stated thus:

$$\frac{P_2O_5}{N} = \frac{1}{5} \qquad \frac{P_2O_5}{K_2O} = \frac{1}{10}$$

In the present manuring formulae, on the other hand, the ratio of P_2O_5 to N varies between $\frac{1}{7}$ and $\frac{1}{3}$, while that between P_2O_5 and K_2O varies between $\frac{1}{3}$ and $\frac{1}{4}$ approximately. The correct manurial balance is therefore not being maintained. A caution is given on the use of nitrogen—an excess being sometimes as harmful as a deficiency. Moreover, ammonium sulphate, one of the most commonly used fertilizers, is by no means the most suitable: as it adversely influences the soil reaction it should be replaced by nitrate, for preference by nitrate of lime.

Phosphorus may be applied in the form of superphosphates, blood, bone-flour, ashes, &c. The extent of soil variation makes it difficult to prescribe definite formulae.

It is also recommended that the application of manures should be carried out on a larger number of occasions especially in the case of nitrate, so that harmful effects which might result from the excessive concentration of salts in proximity to the roots may be avoided.

Treatment of diseased areas and replanting. When the mother plant only is affected it should be cut back till all the diseased tissue is removed. By doing so the daughter suckers may be spared in favourable cases. But when the daughter suckers are also infected the whole plant must be destroyed, and, if possible, all the roots as well. All infected material should be burnt on the spot with oil. The remains of diseased plants should never be thrown into manure heaps, but either burnt or thrown into the sea. The earth which has been moved during uprooting operations should be piled up over the hole and mixed with quicklime at the rate of one part of lime to three parts of soil. The heap is then spread and water sprinkled over until the soil is well soaked.

Lime may be replaced by commercial formalin (40 per cent. formaldehyde solution). This is applied by means of an injector spray at the rate of 60 grammes per sq. metre. If an injecting apparatus is not available the formalin may be applied by pouring a 2 per cent. solution on newly worked soil, if possible on two occasions, at the rate of 10 litres per sq. metre.

Replanting should not be carried out until a few months or preferably a year has elapsed. During this time the land can be utilised for other crops such as potatoes. The bulbs or heads and suckers to be used for replanting should be carefully selected from non-infected areas.

New Plantations.—It is essential that new plantations should be established on land presenting suitable soil conditions so that vigorously growing plants may be obtained. Shallow soils with hard subsoils, and compact, sticky soils liable to water-logging, even for a short time, should not be utilised. Areas insufficiently supplied with irrigation water likewise favour the disease and should not be used for banana cultivation. The quality of the water available should also be examined, saline water being avoided.

If these several preventive and remedial measures are carefully followed, Messrs. Del Canizo and Rodriguez Sardina, the investigators, are prepared to take a hopeful view of the situation. It need scarcely be said that the industry is one of vital economic importance to the Canary Islands. On the other hand, if the apathy shown in the past continues, they believe that it is easy to foresee a fatal and progressive spread of the disease and all the consequences that will inevitably follow in its train.

To readers familiar with the banana industry in general, it will be evident that the remedies recommended by Messrs. Del Canizo and Rodriguez Sardina differ somewhat from those in practice in banana producing countries in the West Indies, *e.g.*, replanting after a few months on infected land, trimming out the diseased parent plant and leaving the apparently uninfected daughter suckers, non-isolation of infected areas by quarantine, &c. With the passage of time it will be interesting to note what measure of success is achieved by the treatments devised by the Spanish for the control of Panama Disease on the Cavendish variety in Teneriffe.

The writer is much indebted to Mr. A. Garces C. for his assistance with translations.

* This view is not necessarily shared by other investigators. According to Baillon, Holmes and Lewis (*Trop. Agriculture*, X, No. V, 1933), the fertilizer mixtures in common use are compatible with the needs of the plant.

STUDIES IN TROPICAL LAND TENURE.

By H. Martin Leake, sc.d.

X.—Summary.

Perhaps the most striking feature that emerges from the preceding studies of the systems of land tenure found in the different tropical components of the British Empire is the extraordinary diversity that exists among these in spite of the fact that, in all cases, their wealth is primarily and dominantly agricultural. The question naturally arises, since land tenure lies at the base of all agricultural production, whether all are equally effective in realizing the potential wealth and securing to the country the benefits arising therefrom. In the following summary an attempt will be made to answer this question and to extract from this diversity those facts which have a bearing on the many unsettled problems in the matter of land tenure in the Colonial Empire.

It is, perhaps, necessary to emphasise that these territories are, and will remain indefinitely, agricultural; for though some may find an additional source of wealth in gold, minerals, or oil, the vast majority of the peoples will depend on agriculture for their prosperity. This is true even in the case of India with its enormous potential capacity as an industrial country. Land tenure, in consequence, in all cases must be considered in its bearing on agricultural production and must take into consideration those fundamental requirements which arise from the fact that such production is the consequence of those vital activities of certain plants and animals which have been summarized at the commencement of these studies. These activities impose definite limits to the various conditions composing the environment and to exceed any one of these limits spells disaster. It is not, therefore, sufficient to bring land and a human being into association; that human being must have, not only a knowledge of those limitations of the organisms he proposes to handle, but a capacity to keep within them. This is an apparently simple proposition but one that is not always recognized in practice. In the case of plantations, sufficient care has not always been taken to determine either the aptitude of the planter or the limitations of the crop; in the case of the indigenous peasant, to ascertain that he has the wherewithal in capital or other requisite to provide the necessary environment.

The above remarks have a general application wherever agriculture is practised. When it is a question of a territory whose source of wealth is purely, or even predominantly, agricultural, a further set of conditions requires to be observed. Such a territory cannot advance far along the path of civilization if it lives as a self-contained unit. With the growth of civilization the luxuries of the simple life become necessaries and such luxuries (or necessities), the products of industrial countries, can only be obtained by import. Imports, again, can only be paid for by exports which, from the nature of the case, must consist of agricultural produce. The provision of an exportable surplus becomes a necessity; but this, alone, is not sufficient. It is necessary that that surplus shall be of a quality acceptable on the world's markets and placed on that market in regulated supply. With the rate at which the tropics have been opened up in recent years and the consequent competition which has grown up in all forms of tropical produce, increasingly exacting conditions of grade are being imposed and supplies which do not attain that grade or which come forward irregularly, will fail to find a market. Not merely production of an exportable surplus, but graded and regulated production is essential for the progressive development of the peoples of such territories. This fact land policy must take into account.

Production for export is no new feature of tropical development. If gold and other forms of minerals provided the stimulus of the early explorers in their search for a route to India, this constituted a passing phase and the realization of the agricultural wealth of the tropical countries which those explorers discovered, soon provided an equally potent and more enduring stimulus. This movement followed two lines which were dictated by the force of circumstances. Where, as on the American continent, the local population failed to offer effective resistance, the land was appropriated and a plantation system of production adopted. Where, however, as in the East, a more virile population existed, capable of offering effective opposition to the available forces, or where, as in West Africa, an unhealthy climate aided the native in his resistance, a system of trading arose which left the land and the system of production in native hands. With the passage of time, the ruthlessness which characterized the conquest of the American continent happily became unacceptable and, though large areas of the tropics came under the influence of European powers, that occupation was accomplished by less forceful methods and did not disturb the rights of the inhabitants in land. Later plantation development became confined mainly to those tracts which lay undeveloped and unclaimed. If, in all this, there is a growing disinclination to interfere with the native and a recognition of his right to live according to his customary ways, there is equally little thought of his welfare; the directing motive is to secure the profit to be derived from the placing of tropical produce on the temperate markets. Competition in these markets had not attained its present severity and they were capable of absorbing all the produce offered.

Only in the last generation has the welfare and progress of the indigenous population come to be accepted as the primary consideration to which all other considerations must give place of precedence. The practical policy by which it is hoped to attain this desideratum, is the maintenance of the indigenous system of administration as far as it is acceptable as a moral code and in that acceptance is included the land tenure system locally in force. As in all primitive countries, that, in its ultimate unit, is a peasant system, the primary function of which is to provide the necessities of the tiller and his dependants. Surplus production is limited to meeting the demands of the chiefs though these demands may become oppressive when the chief is aggressive and requires the sinews of war or seeks his own advancement by trading in that surplus. Consequently latter day policy has concentrated on a peasant system and, in those territories only recently opened up, such a system in all its purity has been adopted. Although the adoption of this policy antedates by so brief a time the intensification of the competition in the markets, there can be little doubt that neither this competition nor the problems to which this competition would give rise, were realized.

Thus the two systems of plantation and peasant have come to be contrasted and it will be of advantage to discuss the main features of the two. The plantation system, as has been stated, is no new development and it possesses a history from which the effect of the pressure of changing economic forces may be traced as they cannot in the case of the peasant system; for, from the first, its main function was to produce for export. The tropical plantation, in its earliest form, reproduced the home system of a personal estate and, as the history of Jamaica particularly shows, these were frequently of a size hardly to be distinguished from peasant holdings. With the advance of an export trade, fostered by home policy and the Navigation Acts, this phase rapidly passed and a process of aggregation took place leading to the formation of large estates, plantations in the common acceptation of the term. The force behind this movement was the nature of the crop, mainly sugar and cacao, yielding non-perishable products which alone could be exported under a regime of sailing ships. Sugar in particular was an expensive crop to grow requiring much labour and, even with the primitive methods of the day, a considerable capital expenditure in manufacture. Finance became a dominant consideration and compelled aggregation. Labour throughout raised important problems, at first solved by the slave trade and later, on the abolition of slavery, by the indenture system.

The next development, characteristic particularly of the East, was rendered possible by the introduction of limited liability. Individual, is replaced by company, control. The tea industry of India, the coffee and, later, the tea and rubber industries of Ceylon and the rubber industry of Malaya follow the earlier plantation system in its main outlines but ownership is, characteristically, impersonal. The financial limitations inherent in personal ownership no longer exert their former pressure and the important problem becomes one of a labour supply, and this was met by an indenture system. Meanwhile economic pressure of another sort was arising in the sugar producing countries. Advances in engineering and chemical technique led to the evolution of the central factory. The economic unit now becomes one entirely beyond individual means and one against which the smaller units are unable to compete. The process of aggregation was thereby still further advanced. The individually owned unit, working on the old open pan system survives only in special localities such as Barbados, where the special nature of the product, syrup, permits its retention, and India where again specialized products, gur and rab, find a ready local market. This aggregation, which is characteristic more particularly of the sugar industry where the complexity of the manufacturing process and the cost of the economic unit have been the compelling forces, is not peculiar to that industry. The more recent pressure of competing production in most tropical produce, largely financial, has produced a like, though less marked, movement in all forms of production. It may be aggregation taking the form of fusion in which the units lose their identity or it may take the form of co-operation such as is found in the numerous associations of producers for marketing.

As distinct from these, there is that most recent development of the plantation system which is to be found in its clearest expression in Kenya. Essentially it is a return to individual ownership and it owes its being to two causes: the suitability of the climate to permanent residence of the European and the nature of the crops grown which require no large expenditure on the preparatory processes. The typical plantation feature of these is their dependence on a labour force.

Of the economic forces which have moulded these various forms under which the plantation system is found, there is one common to them all and one which they have had always with them in greater or less intensity; that of labour. For their success, a paid labour force is essential and throughout, from early times when indigenous labour proved inadequate, through the abolition of slavery to the more recent abolition of the indenture system for the West Indies, Mauritius and Fiji, the plantation system has been faced with labour crises. These crises have not been limited to the British Empire but may be said to characterize the plantation system wherever it

occurs. The reaction to them has been varied. The indenture system itself was, in the West Indies and Mauritius, a reaction to the crisis brought about by the abolition of slavery. At the present time it is the cost as much as the actual shortage of labour that is exerting pressure. Broadly speaking, one of two courses have been followed. At one extreme is the movement to restrict the demand for labour to the minimum and this restriction is achieved by substituting as far as possible mechanical power for manual labour. It is a movement which has proceeded furthest outside the British Empire and is the course adopted in the Philippines and Hawaii, particularly on the sugar plantations. The Sugar Planters' Association of the latter island maintains a Standing Committee on Labour Saving Devices and a good indication of the extent to which mechanization has proceeded is to be obtained from the reports of that committee. Further indication of the effectiveness of this development may be gathered from the address of the President of the Association, in which he states that while in 1910 one man was employed for every 11.85 tons of sugar produced, in 1930 the corresponding figure per man employed was 17.46 tons (1).

At the other extreme is the movement towards a peasant tenantry which has been followed with such marked success in Fiji, while the cane farming movement in the West Indies forms an intermediate development. But while, in all these cases, the labour problem is the immediate stimulus, it is not the fundamental one. Labour is available at a price and the fundamental stimulus is the large increase in production which leads to a competitive cutting of prices rendering the payment of that cost impossible.

It is a general feature of all this development of the plantation system that the evolutionary steps have been taken as the result of economic pressure. An inherent conservatism has perpetuated the existing practice until that pressure has forced a change; and nowhere, perhaps, is that innate conservatism more marked than in Mauritius where the largest mill constitutes too small a unit for true economic working under present conditions. When change has become imperative, the trend of thought has, in the majority of cases, kept to the same lines and, as in Hawaii, what may be correctly termed an intensification of the plantation system has been followed. There are, to this generalization, two exceptions. In the West Indies, notably in Trinidad, the cane farming system, introduced by Sir Neville Lubbock in 1882, constituted a definite departure from the current practice; but, in spite of notable exceptions, that system was not developed to its logical conclusion. Instead, as the history so briefly given in these studies shows, it followed the line of striking balances between opposing forces and a co-operative atmosphere was not created. In Fiji a similar departure was carried to the logical conclusion with the results that have also been briefly recorded.

The peasant system offers for study no such evolutionary history. Till recent times, such produce as drifted onto the world's markets was gathered by traders and, in the early days, the monopoly of such trade led to much international rivalry with little thought given to the welfare of the actual producer. With the modern outlook, which places the welfare of the native and his advancement along the path of civilization in the forefront, production for export has become a major consideration; for it was recognized that only by such export could the materials for a progressive policy be provided. But it may be doubted if any clear recognition existed of the implications lying behind that acceptance and, as with the plantation system, it has required economic pressure to force such recognition. Even now, recognition of all that is implied is very far from general. Only two systems were visualized, the peasant and the plantation systems, each in its purity. Since the latter was clearly incompatible with the modern outlook and aspiration, the latter was necessarily adopted. Under the brilliant advocacy of Lord Lugard the administrative advantages were recognized; the capacity to deliver the goods was assumed. When, as has repeatedly happened, results fell short of expectation, resort was made to the only means open under a strictly peasant system, Government control. Hence the ever increasing complexity of ordinances and regulations controlling agriculture in all its phases; the ever growing responsibilities thrust on the Agricultural Departments and the multiplication of officers attached thereto. These are features characteristic of all those territories where a policy of peasant production has been adopted. Official control of marketing, of systems of planting, of crops permissible and not permitted and of number and type of cattle are some of the features which can be traced in one or other of the territories concerned.

Two questions arise at this point. Can control of this nature be effective and will such control lead to that avowed object, a people capable of standing by itself? The second lies too far outside the range of the present studies to be discussed here; the first merits discussion and there is, fortunately, a certain amount of evidence bearing on the question. Where a peasant system has been organized on strictly commercial lines, it may be assumed with a fair assurance amounting to certainty, that the supervisory staff employed is determined by economic considerations and does not exceed the requirements of efficient management. In Fiji, the area of sugar-cane under peasant cultivation is some 63,000 acres and, for supervision, a considerable staff of overseers is employed. Though the exact number

does not appear to be on record, the number of acres to each overseer cannot be very large. More definite figures are available for that other commercial development on a peasant basis; the Gezira project of the Sudan. In 1926 an area of 300,000 acres, divided into 19 blocks, carried on each block an inspector with two or three junior inspectors; say, a staff of 60 inspectors. One officer was, thus, allowed for each 5,000 acres under the then system in force, a three year rotation with only one-third of the area under cotton. There is here an approximation of the extent of supervisory staff which has been found in practice to be economically sound when the cost of maintaining that staff is debited to the industry. It is a simple calculation to determine from these and from the cultivated area of any territory the cadre of an Agricultural Department for effective development. Two conclusions follow from such a calculation; even the large additions of recent years to the cadres of the Agricultural Departments are inadequate for the task set and an expansion of the cadres to give an approximation to what has been found economically justifiable would impose a prohibitive financial burden on the territory. The fact is that the cost of detailed supervision which the growth of exchange cultures demands, must be carried by the industry concerned and not by the community as a whole.

Here, then, lies the fundamental problem for all those territories which have elected to seek progress through the evolution of the indigenous land system, adapted to a self-contained community, to a peasant system producing for export. Some means have to be found to aggregate these small units, not necessarily, not even desirably, by fusion, so that they become subject to a unified control as regards production for export, and some means have to be found to finance that large supervisory staff required to exercise that control so effectively that each particular product will comply most fully with the exacting requirements of the world's markets while the cost is debited to the industry. It is not merely a question of administration but of finance, for such a trained staff is no inexpensive item; and finance raises the question of security which has, in the past, been sought in a lien on the land itself.

Recent discussions concerning land systems have tended to orientate round the moral aspect of the question. In those countries where an indigenous population is wedded to the land the plantation system is condemned, and rightly condemned, since it involves a repudiation of the titles which local custom has conferred and which have been accepted as valid. Since a plantation system is unacceptable, a peasant system is adopted as the only alternative. The argument is faulty on two grounds; first, it assumes that the peasant system in its purity will yield produce acceptable in the world's markets. There is sufficient evidence that this assumption is very doubtful under the competitive conditions of the present day, and tacit acceptance of this doubt is to be found in the controlling ordinances and regulations to which reference has been made. Second, it assumes that the plantation and the peasant systems are the only two alternatives. That this, too, is an incorrect assumption, practical evidence exists to show.

It is not possible here to discuss the third alternative but its principles have already formed the basis of a series of articles in this Journal (2), where it has been termed a system of vertical co-operation or triple partnership. Nor is it a theoretical system for examples lie to hand of the successful working of such a system. In the Sudan the Gezira project has attained fruition under this system which has been directly superimposed on an indigenous peasant system with titles of ownership established under native custom and accepted as valid. The project illustrates the system of vertical co-operation in its full development and such weakness as it possesses lies in the fact that, for prosperity, it is dependent on a single crop and lacks the insurance given by a multiplicity of products. The sugar industry of Fiji offers a second example. It is a development from the plantation system. A body capable of organizing the necessary supervision and finance was already in existence and a tenantry of peasants was created. But the system has been found capable of extension to include peasants holding under the native system. The elements of a third example are present in the development in northern India which centred round the tube well and which has been briefly described above (3). Here, in the zamindar, lay to hand a potential centre around whom the system might be built up. That the movement did not proceed far was due to no inherent weakness of the principle but to the action of a time factor. It was the rapid rise of prices during and immediately following the War that afforded the opportunity, in that the zamindar was tempted to turn his attention more directly to agriculture. But the boom was too short lived to break down the habit of regarding his estate primarily as a source of income from rents. A mental outlook built up during the centuries is not so rapidly broken down.

One feature of this third system of vertical co-operation which the above examples bring into prominence, is the great flexibility inherent therein. More widely divergent starting points could hardly be imagined than those found in the Sudan, Fiji and India; yet in all three cases the same principles have been found to be applicable. The two former offer yet one further object lesson. In both it is the force of economic pressure, in the Sudan the capital involved in the dam and irrigation works, in Fiji labour troubles, which has forced the adoption

of the system. That it was the system of vertical co-operation that was adopted in both cases is due to the fact that those responsible for working out a solution of the practical problem with which they were faced, were tied by no rigid preconceptions and regarded the problem from no narrow outlook. The fact that the fundamental principles are the same in the systems adopted successfully in these two independent developments, offers strong presumptive evidence that those principles will be found to have wide application even when the economic pressure is non-existent.

Most of the arguments which have been advanced in support of the peasant system are of a negative character. The plantation system is unacceptable and therefore, the peasant system must be adopted as the only alternative. It is unnecessary, therefore, to argue these, for they rest on a false assumption. There is, however, one argument of a somewhat different nature to which brief reference may be made. It is held, that, under a peasant system when prices recede, a lapse to a self-contained unit is more readily achieved than under a plantation system. That may be true but the argument ignores the community as a whole and considers only the peasantry. If there is any meaning in communal advancement to a position when that community will be able to stand by itself, other elements will have developed within the community, not directly dependent on the land and grown accustomed to a standard of living in which the manufactured imports will figure as necessaries. If the peasant can revert to the simple life, these cannot and a cessation of exports and, consequently, of imports, can only lead to grave social upheaval. The fact is that a maintenance of exports will become more and more imperative as social evolution towards the ideal progresses.

Since the plantation system in its purity is clearly unacceptable, and since the peasant system in its purity cannot provide the requirements of a secure export trade in agricultural produce, the potentialities of the third system, that termed vertical co-operation, require to be explored. Passage to it from the plantation system is relatively free from sociological problems for it consists in the conversion of a paid labour force to a tenantry the relative freedom of which, as experience shows, appeals to those in whom any trace of an agricultural instinct exists. The passage to it from a peasant system presents a more complex problem. The peasant is attached to his land and will regard any limitation of his agricultural activities with suspicion and as a potential threat to his security. The problem is one for which a solution has hardly been sought, yet it is the problem which faces the administrations of all those territories which have adopted a peasant system. It is essentially a problem of land tenure and a first step towards a solution must be a clarification of the existing system as established by native custom, for both the starting point and the goal must be equally clearly defined if false steps are to be avoided.

As these studies are designed to show, native custom in the matter of tenure varies widely, but from that diversity certain conclusions may be extracted. The intensity of the recognition of a right in land grows with increasing pressure of population. With that increased pressure, too, is associated a growing recognition of personal ownership. There is here clear indication that native custom in this matter is no inflexible rule permanently established for all time but an evolutionary code capable of adjusting itself to changing conditions. This evolutionary character is well exemplified in the varying customs of the Kikuyu. Within native experience changes have arisen either through growing pressure on the land or through the development of a certain non-agricultural section within the community. Contact with the outer world has, on the one hand, intensified the pressure by diminishing the forces of reaction, tribal warfare, slavery, disease and famine; on the other hand, it has introduced a new force for meeting which native custom has no precedent. This force is the export trade which has sprung up in recent years and it falls to the various Administrations to guide the further evolution of the systems of tenure to meet these new conditions. The difficulty lies less in the actual process of adjustment than in the speed at which those adjustments must be made. The difficulties which only too plainly beset the question, will be lessened by a recognition that native customary tenure is not a static condition to be perpetuated, but itself intrinsically evolutionary.

The study of this problem has been complicated by the fact that land tenure is not a subject which stands by itself; it is intimately bound up with the question of taxation. In an agricultural country the produce of the land must form the main source of revenue, and argument only centres on the relative advantages attaching to the different points at which it may be tapped. Those arguments have been reviewed in great detail by Lord Lugard in his Dual Mandate and need not be considered here. Ideally they should be a tax on production but the practical difficulty lies in the fact that production is liable to wide seasonal fluctuation. These practical difficulties cause the assessment to be made usually for a number of years and this introduces a further complexity; for if, as is usually the case, the assessment be fixed in money values, the changes which occur in the market value of produce are ignored.

Assessments of 30 or 40 years are commonly found in the systems adopted in the various territories and there can be little doubt that

their inspiration may be traced to India. Assessment of land revenue, in reality of potential productive capacity of land, was the system developed during the Moghul dynasty but adopted and carried to its present stage of perfection under British rule. It has proved wonderfully successful, but it would appear that that success was due to the fact its detailed evolution took place during a period of slowly increasing prosperity when a gradual upward adjustment of prices, from local to those of the world's markets, was in progress. Even the depression of the latter part of last century had little effect, for India was on a silver basis. Under such relatively stable conditions a 30-year period was none too long. When, however, the world's price level was reached, these conditions no longer prevailed; the steady rise has been replaced by a period of violently fluctuating prices and the weakness of the periodic assessment has been exposed. An illuminating account of these weaknesses has been given by Burn (4). The periodical assessment is, in fact, an approximation to an average only; its disadvantages are that, if placed at an equitable average level, in some years it will be too low and in others too high. A necessary concomitant is an organized system for granting remissions, an unsatisfactory and invidious process. It is ill adapted to periods of violent price fluctuations and recent experience has shown it to be too rigid a system.

Assessment, however, is not merely used to determine revenue capacity; it provides an opportunity of securing to the state an adequate share in the incremental values which accrue when undeveloped territories are opened up. It is a weapon against land speculation, for use particularly where a plantation system is in process of development. As such it is a valuable weapon, the throwing aside of which, as the history of Bengal indicates, is fraught with danger.

But there are other disadvantages of this association of taxation and land tenure. The latter has inevitably come to be regarded primarily from the purely administrative aspect and its vital bearing on production overlooked. In this lies the weakness underlying the system of administration in those territories where a peasant system is dominant. It is a weakness that is exemplified in startling manner in the terms of reference of the Royal Commission on Agriculture in India which lay down that :—

> . . . it will not be within the scope of the Commissioners' duties to make recommendations regarding the existing system of land ownership and tenancy or of the assessment of land revenue . . .

By this limitation the Committee were precluded from examining the most fruitful line of development towards agricultural prosperity that India offers.

The system of vertical co-operation in its complete form of triple partnership, is free from the drawbacks seen to be inherent in the periodic settlement. It is a true partnership between the peasant, the productive organization and the state by which the revenue is automatically adjusted to actual production and by which the state reaps its share of the incremental value. The maximum flexibility is attained.

In the introduction to these studies it was indicated that a land tenure system must be judged by two standards, an economic standard, its capacity to supply that export trade which is an essential to progress, and a sociological standard, its capacity to afford opportunities to the component sections of the community to develop their innate capacities. Unless both are satisfied, disappointment will result. These studies show fairly conclusively that the peasant system fails to attain the former standard, for it fails to satisfy the five tests laid down. Crops that require large capital expenditure for the preparatory processes or a high degree of organization in placing them on the market are not grown under this system while, where those requiring organization of the methods of production or for prevention of disease are grown, the tendency is towards official regulation of every growing complexity. While the plantation system provides more fully these requirements, it is only possible in thinly populated tracts and even then its adequacy is extremely doubtful. But there has been described in these studies a third system which provides the necessary conditions more fully and to which, practical experience has shown, the two older systems may be adapted. With the sociological aspect these studies have only this concern, that it is clearly necessary to determine, before drawing constructive conclusions from them, that these contain nothing that is incompatible with the social requirements. Inasmuch as one of the developments concerned, that in the Sudan, has taken form from native tenure, it may be accepted that such incompatibility does not exist. From the quoted official reports on the sociological effects in the second case, that of Fiji, it is possible to go further and conclude that the system possesses sociological advantages over the other two.

References.

(1) Rept. 51st Ann. Meeting, Hawaiian Sugar Planters' Assn., 1931.

(2) *Tropical Agriculture*, VII, 1030, pp. 210, 240 and 269.

(3) *Tropical Agriculture*, IX, 1932, p. 248.

(4) Recent Rent and Revenue Policy in the United Provinces; Sir Richard Burn, *J. Roy. Soc. Arts*, LXXX, 1932, p. 659.

TOMATO STORAGE.

Further Observations on the Storage of Tropically Grown Tomatoes.

By C. W. Wardlaw and L. P. McGuire.

Introduction.

In a former report (3) it was shown that tropically-grown tomatoes, as exemplified by good Trinidad fruit, picked full-grown but green, could be successfully held in cold storage at 47.5°F. for periods up to 20 days and thereafter ripened and held at 70°F. for 10-14 days without undue wastage, provided certain conditions were observed.

The influence of pre-storage factors—soil and climate—on the keeping quality of other perishable vegetable commodities is well known, and it was realised that tomatoes grown elsewhere, or in a different season in Trinidad, might not necessarily behave in storage as satisfactorily as those used in our experiments. In point of fact, this has actually proved to be the case and in some Islands the tomatoes, on removal from cold storage, are reported to have undergone rapid degeneration.

By analogy with other fruits this was perhaps attributable to the soil conditions under which the tomatoes were grown. To throw light on this point, a series of plots was laid out by the College Department of Agriculture on which the Bonnie Best variety was subjected to different manurial treatments as follows :—the whole experimental area was first treated with a dressing of farmyard manure at the rate of 12 tons per acre; (i) plots without further treatment served as controls; to other plots were added (ii) ammonium sulphate at the rate of 200 lb. per acre, (iii) superphosphate at the rate of 400 lb. per acre, and (iv) muriate of potash at the rate of 200 lb. per acre.

The behaviour of the crop under the four manurial treatments and the incidence of diseases and pests in the field have been subjects of special observation by Messrs. N. M. Wight and E. J. Butler* in their Post-Graduate studies. The present paper is concerned only with the fruit which could be regarded as suitable in size and quality for storage experiments.

Storage Trials.

In all, three storage trials were undertaken. Following the experimental method outlined in our earlier work (3), the consignments of full-grown but green tomatoes were graded into uniform lots and held at 47.5°F. for 17 days, with subsequent ripening at 70°F.

Useful information on manurial treatment which, it was hoped, would accrue from the aforementioned field experiments has not, unfortunately, been forthcoming. The prolonged period of rains in 1932 and the slow advent of dry weather in 1933 have exercised in this, as in some other crops, a profound influence on the profusion and intensity of fungal infections. Thus, in the first trial conducted by Messrs. Wight and Butler the several lots of fruit, on removal from cold storage, showed fungal wastage ranging from 27-49 per cent. As this was a rather immature grade of fruit, as evidenced by the small percentage showing colour after 17 days at 47.5°F., it may safely be inferred, from the nature of the diseases, that their incidence under field conditions was very great indeed. Many of these first become established as latent infections on green fruit and only develop later during storage. In our earlier experiments (3), the highest percentage of wastage ever recorded in green fruit held at this temperature from 15-20 days was 6 per cent. in the Stone variety: usually wastage on the first day at 70°F. was only 1-3 per cent. In their second storage trial, wastage was even more severe, 17-95 per cent. of the tomatoes having to be rejected immediately on removal from cold storage. In this consignment the fruit was of a more mature grade, 50 per cent. approximately being partially coloured at this time. In view of (i) the excessive rejection of fruit at an early stage in the ripening room, and (ii) the variation encountered on analysing the results for the several consignments, it has proved quite impossible to make any constructive observation on the merits of the different manurial treatments as regards their effect on cold storage potentiality.

In a third storage trial, undertaken by the writers towards the end of the fruiting period, a rather different result was obtained. The relevant data are set out in Table I.

In addition to these figures, which indicate the normal rejection obtained by using commercial criteria, a further analysis was made of the nature and number of infections on each individual fruit (Table II). Infections localised round the stem end or button are described as "Button Infections", those originating at the insertion of the style as "Stylar Infections", while other disease spots and blemishes distributed over the surface of the fruits are referred to as "General Infections". The results, stated as number of infections per cent. refer to the entire consignments. The percentage infection, *e.g.*, 230 per cent. total infection in the instance of fruit from the sulphate

*Their records and conclusions will be available later in an unpublished dissertation in the College Library. We have pleasure in expressing our thanks to them for their assistance in this work.

Table I.

Record of Wastage in Tomatoes.

(Stored full-grown but green at 47.5° F. for 17 days and thereafter ripened at 70° F.)

Manurial Treatment.	Percentage Wastage* in Ripening Room after:		
	3 days.	7 days.	12 days.
Sulphate of ammonia..	4.5	31.0	62.0
Superphosphate ..	0.0	13.0	25.5
Muriate of Potash ..	2.0	12.0	24.0
Control	2.0	20.0	40.0

of ammonia plot, may, at first sight, seem disproportionately high. When it is considered, however, that some fruits showed 3, 4 and 5 separate infections at the button end and others as many as 11, 13 and 31 general infections, these figures will no longer be regarded as surprising. It will be seen that this method of assessing wastage gives results comparable with those in Table I.

Although the wastage shown in Table I is still much greater than that experienced in former investigations, the results nevertheless are in keeping with what might have been anticipated on general grounds. The rôle of nitrogen in increasing susceptibility to disease and of potash in decreasing it, and the known sensitiveness of the tomato plant in particular to phosphate deficiency (2) are facts not incompatible with the data set out in Tables I and II. We regard it as unfortunate, therefore, that the crop came to an end before these observations could be confirmed or modified by a fourth storage trial. In the circumstances, while the data quoted are interesting, it would be definitely premature in our opinion, to regard them as providing the information required in devising appropriate manurial treatments.

In all three storage trials, wastage has been entirely due to the activities of micro-organisms. The peculiarities of weather conditions during the growing period, *e.g.*, the late advent of the dry season has undoubtedly been the chief contributory factor in the high incidence of

* These figures are cumulative.

Table II.

Types of Infection after 12 days at 70°F. (stated as number of Infections per cent.).

Nature of Wastage	Sulphate of Ammonia	Superphosphate.	Muriate of Potash.	Control
Button Infections	124	18	38	67
General Infections	102	18	44	73
Stylar Infections	4	2	0	2
Total Infections	230	38	82	142
Total Wastage (as recorded in Table I).	62	25	24	40

diseases. The somewhat different results obtained in the third trial, namely, considerably less wastage than in the first and second trials, is accounted for by the onset of drier weather. Other samples of fruit examined subsequently, which had been grown when typical dry season conditions were more or less established, were remarkably free from infections.

One positive result, however, has emerged from the several storage trials, namely, that fruit which had escaped fungal infection did not undergo rapid degeneration on removal from cold storage. This confirms our previous contention that the tropically-grown tomato, as exemplified by good Trinidad fruit, is physiologically so constituted that it possesses good keeping quality, provided fungal wastage can be kept in abeyance.

Mycological Observations.

The following organisms were isolated from, or observed in association with, the various fruit spots and soft rots:—*Phoma destructiva* Plowr.; *Fusarium succisae* (Schroet.) Sacc.; *Fusarium semitectum* Berk. and Rav.; *Fusarium* spp.; *Phomopsis* sp.; *Helminthosporium* sp.; *Macrosporium* sp. (saprophytic species agreeing with that described by Rosenbaum, *Phytopath.*, X, pp. 9-21, 1920); *Glomerella cingulata* (Stonem.) Spauld. and Von Schrenk.; *Botryodiplodia theobromae* Pat.; *Bacillus aroideae* Towns.; *Bacillus* sp.

Table III.

Occurrence of Fungi and Bacteria in Rejected Fruit.

	Number of Occurrences.
Phoma destructiva	205
Fusarium succisae	7
Fusarium semitectum	3
Fusarium spp...	20
Phomopsis sp...	6
Helminthosporium sp.	2
Macrosporium sp.	3
Glomerella cingulata	2
Botryodiplodia theobromae ..	2
Mixed fungal and bacterial infections	4
Total..	254

Table III shows the occurrence of the several organisms in rejected fruit. The preponderance of *Phoma destructiva* was the outstanding feature of the three storage trials, individual fruits sometimes having as many as 11, 13 and 31 separate infections distributed over the surface. In other instances 3, 4 and 5 separate *Phoma* infections had become established in proximity to the button. These were sometimes followed by spreading soft rots in which species of *Fusarium* and *Phomopsis* were involved. In general, the fungal flora was closely comparable with that observed in previous years (3).

A brownish discolouration of the vascular strands in the placentae, usually in proximity to the button but sometimes occupying a more central position, was present in many fruits, in some samples at least 20 per cent. being affected. This malady was not observed in previous years either by Briant (1) in his field studies nor by ourselves during storage trials. It has yet to be determined whether this additional source of wastage is physiological in origin or whether it may be attributed to a virus or bacterial agency.

Summary.

1. The influence of pre-storage nutritional factors on the subsequent behaviour of tropically-grown tomatoes requires investigation as it has been reported that some consignments of fruit, on removal from cold storage, have undergone rapid degeneration.

2. Storage trials, conducted during the current year with the Bonnie Best variety grown on plots with different manurial treatments, have largely been defeated by the high incidence of fungal infections, the fruit, on removal from cold storage in two trials out of three, showing a proportion of rejects far exceeding the 10 per cent. usually allowed by the Trade.

3. In these experiments fruit which had escaped fungal infection did not undergo rapid degeneration on removal from cold storage (17 days at 47.5F°.) but appeared to possess good keeping quality, thereby confirming our earlier findings regarding the tropically-grown tomato.

4. The causes and the nature and extent of wastage are briefly described.

In conclusion the writers desire to express their indebtedness and thanks to members of the staff of the College Department of Agriculture for their co-operation in this work.

References.

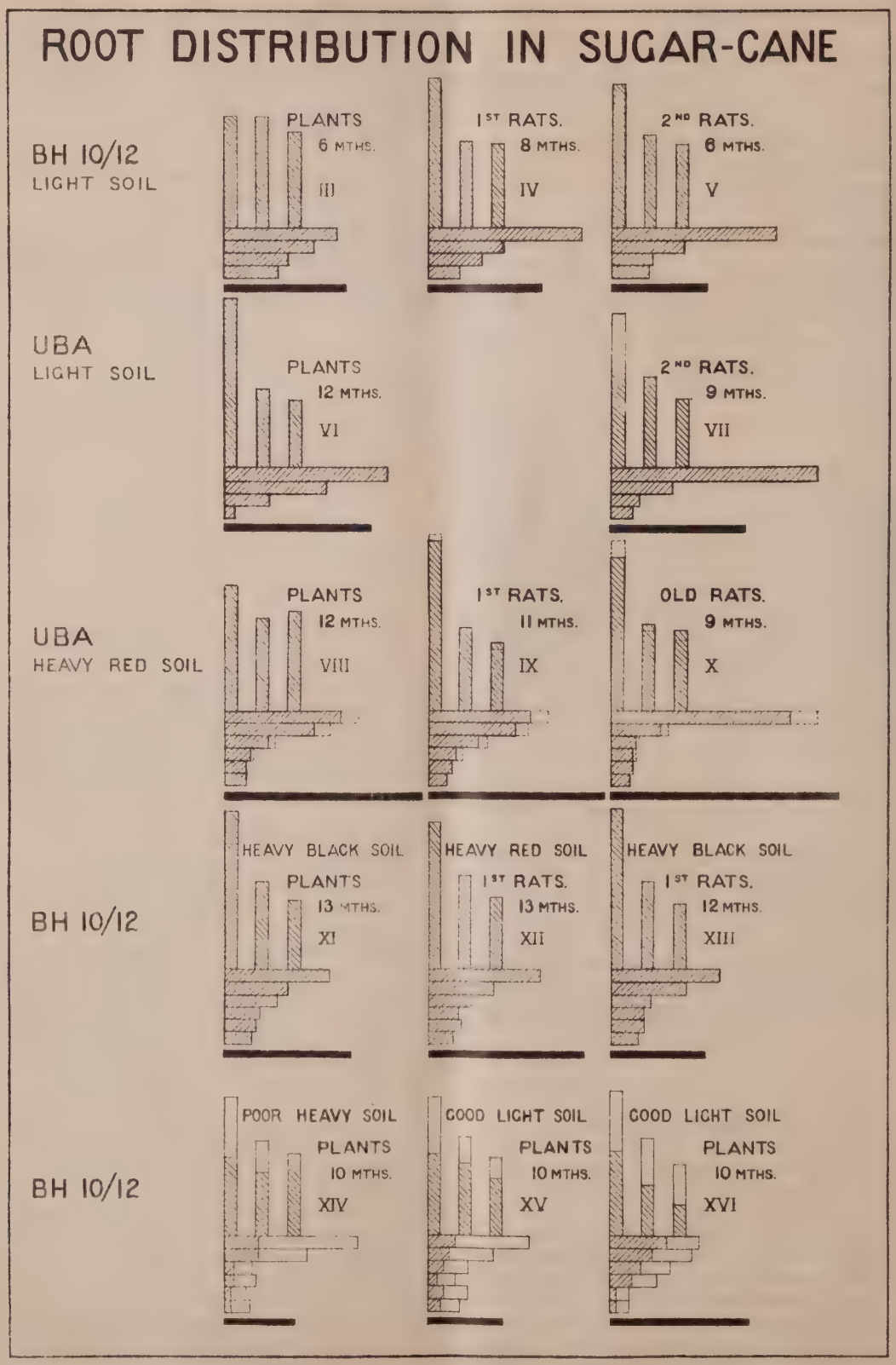
1. Briant, A. K.—Tomato Diseases in Trinidad. *Tropical Agriculture*, IX, 2, 1932.

2. McDonald, J. A.—A Sensitive Pot-Test for Phosphate Deficiency in Soils. *Tropical Agriculture*, X, 4, 1933.

3. Wardlaw, C. W. and McGuire, L. P.—The Storage of Tropically-Grown Tomatoes. Empire Marketing Board Report, No. 59, 1932. Published by H.M.S.O. (Précis in *Tropical Agriculture*, IX, 2, 1932.)

PAPAYA CULTIVATION.

An article in *Agriculture and Livestock in India*, Vol. V, 1932, discusses the establishment of plantations of papaya chiefly with a view to the extraction of papain on a commercial basis. The fruit after tapping may be marketed, though prices are lower than for untouched fruit. Balance sheets showing costs of production of an actual profit earning papaya plantation are given covering a period of four years from the starting of the plantation. The plantation should not contain trees more than four years old. Of the fruits tested the most productive of papain was the Bombay variety. The juice is extracted from the fruit by lancing with a sharp knife of horn, ebony or stainless steel. Iron or ordinary steel will spoil the colour of the product after drying. The cuts, four in number and evenly distributed, are made in a straight line along the fruit from the stem to the apex, the exuding juice being collected in enamel or earthenware dishes held beneath the fruit. The drying which should be done at once, when on a moderate scale can be efficiently carried out in an apparatus (illustrated) consisting essentially of a metal sheet surmounted by a glass drying plate on which the juice is spread in the sun, with a glass cover and adequate ventilation. After drying, the papain is reduced to powder by grinding with an ordinary porcelain pestle and mortar and sieving. If produced on a large scale, the method employed for drying milk might be used, namely spraying the juice into warm air and collecting the dust. Directions are given for testing the purity of the product.—(*Horticultural Abstracts*, Vol. III, No. 1.)


ROOT DISTRIBUTION IN SUGAR-CANE
BH 10/12
LIGHT SOIL
PLANTS
6 MTHS.
III
1ST RATS.
8 MTHS.
IV
2ND RATS.
6 MTHS.
V
UBA
LIGHT SOIL
PLANTS
12 MTHS.
VI
2ND RATS.
9 MTHS.
VII
UBA
HEAVY RED SOIL
PLANTS
12 MTHS.
VIII
1ST RATS.
11 MTHS.
IX
OLD RATS.
9 MTHS.
X
BH 10/12
HEAVY BLACK SOIL
PLANTS
13 MTHS.
XI
HEAVY RED SOIL
1ST RATS.
13 MTHS.
XII
HEAVY BLACK SOIL
1ST RATS.
12 MTHS.
XIII
BH 10/12
POOR HEAVY SOIL
PLANTS
10 MTHS.
XIV
GOOD LIGHT SOIL
PLANTS
10 MTHS.
XV
GOOD LIGHT SOIL
PLANTS
10 MTHS.
XVI

ROOT DISTRIBUTION OF SUGAR-CANE IN DIFFERENT SOILS IN TRINIDAD.

Embodying Some Results Obtained by a Soil-Core Method.

By F. Hardy.

(I)—Introduction.

Root studies of the sugar-cane plant have been undertaken by various investigators who have employed different methods for obtaining representative data. The methods may be classified into two main categories, namely, (*a*) Qualitative (graphic or direct examination), and (*b*) Quantitative.

(*A*) *Qualitative Methods.*

These are based on profile dissections in pits or trenches dug alongside the plants whose root-systems are to be studied. The method is essentially that used extensively by Dr. J. E. Weaver (8), who has employed it in the United States of America for characterising and comparing the root-systems of different members of various natural plant associations (such as prairie-grassland and forest), and of various crop plants. In Weaver's monographs, root features are displayed in numerous diagrams drawn to scale, and in a series of photographs. The method is very tedious and time-absorbing, and it yields results that are difficult to compare and to correlate. Weaver's method has been applied to sugar-cane by Venkatraman and his co-workers in India (9, 10), and more recently by Jensen in Cuba (4).

A modification of the method, due to Venkatraman, involved special plantings of cane-sets in pits which had been previously excavated and then fitted with platforms of wire-netting at spaced intervals, during the refilling of the pits with soil. When the sets had grown, the pits were reopened, and the soil washed away, leaving the root systems suspended in the meshes of the netting. In later experiments, the pits were replaced by a series of superimposed earthenware shallow cylinders, having wire-netting stretched between the segments of the column. In each case, the root systems were photographed or charted to scale, and their dimensions determined. A similar method, involving the use of special boxes, was employed by Weller (11) and by Wolters (12) in Hawaii, and by Roxas and Villano in the Philippines (7), for investigating the effect of manures on sugar-cane root-development.

(*B*) *Quantitative Methods.*

These usually involve sectional excavation and sieving. The soil within a marked area surrounding the growing plant is removed in measured layers, and the roots included in it are separated by passing the soil through a suitable screen. Unless the soil is very friable and dry, sieving is tedious, and the necessary separations take a long time to complete. The root material from the different layers is dried and weighed. If desired, it may be subdivided into old thick roots and young soft roots, which may be weighed independently. The method has been applied to sugar-cane by Atherton Lee in Hawaii (1926) (5), and also by Weller (1928), and by Wolters (1929) in Hawaii, and by Roxas and Villano (1930) in the Philippines. Attempts made by the writer (1927) to apply it to sugar-cane growing in wet, sticky, clay-lands occurring in southern Trinidad were not successful, because of the difficulty of separating the roots from the soil, which necessitated recourse to lengthy washing instead of dry sieving (3).

Another method of quantitative root-study as applied to cotton plants in Turkestan, was described in 1925 by F. M. Mauer (6), who used a steel tube of diameter 3½ inches and length 4 feet, which was forced into the soil around the plants. Cores of soil, containing roots, were thus obtained for successive layers of four inches thickness, down to the three-foot depth. Sampling was repeated at several spots in order fully to explore the root-systems. The cores were washed in a sieve so as to separate the cotton roots, which were afterwards dried and weighed.

(II)—Soil-Core Method applied to Sugar-Cane.

The soil-core method, described in the last section, has been applied by the writer to a study of sugar-cane root distribution in Trinidad. The sampling tool used is an edge-sharpened steel tube of internal diameter 3 inches and length 40 inches. Its walls are ⅜ inch thick, and the unsharpened end is furnished with a strengthening band, 1½ inches deep, and with a loose-fitting cast-steel flanged plug. The tube is driven to suitable depth into the soil by means of a sledge hammer, and then withdrawn, after loosening by shaking or tapping, by means of cross-pieces of steel tube which slide into one-inch holes bored through the top of the tube. In moist soil, the labour involved in obtaining soil-cores is by no means excessive, and two men can procure six 6-inch depth-samples at fifteen to twenty sites within one working day of eight hours (90 to 120, 6-inch cores in all).

In the laboratory, the soil-cores are placed in basins of water and left overnight. Next day, the root contents may readily be separated by sieving through a 1-mm. sieve, in running water. The root material is then dried and weighed. It may afterwards be hand-picked into old roots and young roots if necessary, and each portion separately weighed.

PROCEDURE IN THE FIELD.

Preliminary trials were made by taking cores at successive 6-inch depths down to two feet, at three equally-spaced positions along each of three symmetrical radii centering on a single cane stool. To aid in the spacing, a wooden guiding board in which three holes had been cut, each of diameter 3¾ inches, with centres seven inches apart, was employed. This was laid flat on the ground with one end in close contact with the cane stool. The margin of the first hole was one inch from the contact end, so that cores, cut vertically through the guiding holes of the board, explored the root-containing soil surrounding the plant, downwards to a depth of two feet, and outwards to a distance of about 18 inches, along each of three radii. Since canes are planted in Trinidad approximately three feet apart in the rows, the complete root-system of the stool (with the exception of roots lying vertically below the stool base) was symmetrically sampled in 6-inch layers down to the 24-inch depth.

Results obtained by this method showed that the distribution of roots within the soil surrounding individual cane stools was somewhat irregular, but that the irregularities could not be correlated with the effects of neighbouring drains, nor with the position of the stool within the cane-row or cane-bed. Consequently, it was decided in preference to sample any given stool by obtaining cores along one radius only, and to replicate the sampling for the purpose of procuring more reliable average data, by repeating the operation for five selected stools, as nearly similar as could be judged by inspection, growing within a small area of uniform soil.

Thus root studies of any particular cane variety of known age and stage of growth, planted in any particular kind of soil, involved the collecting of five (stools) by four (depth samples) by three (radius-sites), *equal* 60 soil-cores, from which root material was abstracted by washing and sieving. Later, the depth of sampling was increased to 36 inches, instead of 24, so that each experiment subsequently involved the collecting of 90 soil-cores. In three experiments, small white roots were separated from large black roots and each kind was weighed separately.

(III)—Results Obtained.

SERIES A.—WATERLOO ESTATE, TRINIDAD.

Experiments I to VII.

The soils of this area are mainly derived from Swamp and Lagoon Alluvium, which varies from light compact sand to stiff hard clay. In the first series of experiments, the distribution of roots was explored vertically to a depth of 24 inches in four successive 6-inch layers. Two contrasted types of cane were selected, namely, BH 10/12 and Uba, of similar age but in different stages of growth, *i.e.*, plant canes, first ratoons and second ratoons.

Experiments I and II. (B. 6308, 3rd Ratoon Canes, seven months old). Heavy *versus* Medium-Light Soil.

In these paired experiments, two somewhat different soils were compared as regards their root contents. Each soil supported the same variety of sugar-cane in the same stage of growth, and of approximately the same age. In order to test the degree of variability of the numerical results, each experiment was repeated four times (four groups of five stools each). The full data for the first trial of Experiment I (heavy soil) are presented in Table I, which also contains (in the bottom right-hand division) the *average percentage values* for weights of roots, arranged so as to show their *lateral* distribution (in columns A, B, C), as well as their *vertical* distribution (in four successive 6-inch layers). In Table II, percentage values are given for each of the four trials of each of the two experiments (heavy *vs.* medium-light soil). Finally, the averages of the mean percentage values are set out side by side for comparison. Total weights of root material, included in the collected soil-cores, are presented in each case.

CONCLUSIONS.

The results do not demonstrate significant differences between the distribution of roots in the two contrasted soils, although they indicate that root growth is rather more superficial in the medium-light soil. Actually, the soils were not very different in texture (Index of Texture Values (1); heavy soil, 46 (Waterloo, Field 9); medium-light soil, 32 (Camden, Field 13)), and both were tightly packed and poorly drained. The yields of cane also differed; actual measurements showed that the average weight of a stool of cane stems growing in the heavy soil was approximately twice that of a stool of canes growing in the lighter soil (17.1 lb. against 8.3 lb.), although the weights of collected roots were not very different (1205 cgm. against 1009 cgm).

The fair regularity of the numerical results obtained in Experiments I and II appeared to justify the procedure, and the method of study was accordingly extended to other problems of sugar-cane distribution in Trinidad.

Experiments III, IV and V. (BH. 10/12; Age, 6 to 8 months, Light Soil).
Plants *versus* Ratoons (BH 10/12).

The soil-type, as before, was Swamp and Lagoon Alluvium, but the texture was that of a sand (Index of Texture varying between 12 and 8). The fields were selected from Exchange Section, Waterloo Estates. The results obtained (percentages) are presented in Table III, and are graphically displayed in Diagrams III, IV and V.

In the diagrams, the vertical columns represent the mean weight percentages of collected root material obtained at three points (A, B, C) along radii running from the bases of the selected five stools along a bed (*i.e.*, parallel with the drains), and in the centre row of the bed (lateral distribution. The horizontal layers of the diagrams likewise represent the mean weight percentages of root material obtained from four successive 6-inch layers (depth distribution). The horizontal thick black lines represent the average total weight of root material collected from a single stool.

CONCLUSIONS.

Reference to Table III and to the corresponding diagrams, indicate that root distribution for plant canes, first ratoons and second ratoons differs markedly, other factors (cane variety, age of cane, and soil type) being approximately, equal.

Table I.

Root Distribution Data for B 6308, 3rd Ratoons, Heavy Soil (Waterloo Estates).

(*Root weights in Hundredths of a Gram*).

TRIAL (I).

STOOL I.

Layer, inches.	A	B	C	Sum.	Per cent.
0-6	222	103	132	457	36
6-12	320	125	109	554	43
12-18	73	44	34	151	12
18-24	48	37	35	120	9
Sum	663	309	310	*Total*	
Per cent.	51	24	24	1282 cgm.	

STOOL III.

Layer, inches.	A	B	C	Sum.	Per cent.
0-6	187	132	276	595	56
6-12	111	95	77	283	27
12-18	45	28	37	110	10
18-24	31	25	24	80	7
Sum	374	280	414	*Total*	
Per cent.	35	26	39	1068 cgm.	

STOOL II.

Layer, inches.	A	B	C	Sum.	Per cent.
0-6	270	230	155	655	46
6-12	223	117	111	451	31
12-18	69	81	60	210	15
18-24	47	38	29	114	8
Sum	609	466	355	*Total*	
Per cent.	43	33	25	1430 cgm.	

STOOL IV.

Layer, inches.	A	B	C	Sum.	Per cent.
0-6	228	142	172	542	43
6-12	164	115	115	394	31
12-18	73	96	66	235	19
18-24	36	28	27	91	7
Sum	501	381	380	*Total*	
Per cent.	40	30	30	1262 cgm.	

STOOL V.

Layer, inches.	A	B	C	Sum.	Per cent.
0-6	324	172	184	680	47
6-12	182	113	107	402	27
12-18	116	71	70	257	18
18-24	40	37	39	116	8
Sum	662	393	400	*Total*	
Per cent.	47	27	27	1453 cgm.	

TRIAL (I).

AVERAGE VALUES (5 stools).

	Columns.			*Layers.*			
	A	B	C	0-6 inches.	6-12 inches.	12-18 inches.	18-24 inches.
I	51	24	24	36	43	12	9
II	43	33	25	46	31	15	8
III	35	26	39	56	27	10	7
IV	40	30	30	43	31	19	7
V	45	27	27	47	27	18	8
Av.	43	28	29	45	32	15	8

Av. Total wt. 1300 cgm.

Table II.

Comparison of Root Distribution Data for B. 6308, 3rd Ratoons, in Two Different Soils (Waterloo Estates).

(*Percentages of Total Root Weights.*)

EXPERIMENT I.—HEAVY SOIL.

B. 6308.	Trial (1).				Trial (2).				Trial (3).				Trial (4).			
Columns	43	28	29		40	32	27		38	31	31		40	31	29	
Layers (4)	45	32	15	8	39	33	20	10	42	28	20	10	44	28	18	10
Total root weight ..	1300 cgm.				1153 cgm.				1170 cgm.				1197 cgm.			

EXPERIMENT II.—MEDIUM LIGHT SOIL.

B. 6308.	Trial (1).				Trial (2).				Trial (3).				Trial (4).			
Columns	43	30	27		39	32	29		44	29	27		42	30	28	
Layers (4)	43	30	14	13	52	22	16	10	50	28	12	10	48	27	15	10
Total root weight ..	1064 cgm.				947 cgm.				1016 cgm.				1008 cgm.			

COMPARISON OF AVERAGE VALUES.

Averages.	Experiment I. Heavy Soil.				Experiment II. Medium Light Soil.			
Columns	40	31	29		42	30	28	
Layers (4)	42	30	18	10	48	26	15	11
Total root weight.	1205 cgm.				1009 cgm.			
Average Stool.								
Weight of stems	17.1 lb.				8.3 lb.			
Height	63 inches				54 inches			
No. of stems	11				9			
Circumference of stems ..	4 inches				3¼ inches			

Table III.

Comparison of Root Distribution Data for Three Different Stages of Growth of BH 10/12 Canes in Light Soil (Waterloo Estates).

(*Percentages of Total Root Weights.*)

BH 10/12.	Experiment III. Plant Canes.				Experiment IV. First Ratoons.				Experiment V. Second Ratoons.			
Columns	35	35	30		47	27	26		45	29	26	
Layers (4)	35	28	20	17	49	24	17	10	52	23	13	12
Total root weight ..	1119 cgm.				1071 cgm.				908 cgm.			
Average Stool.												
Weight of stems ..	18.4 lb.				13.1 lb.				13.4 lb.			
Height	80 inches				72 inches				66 inches			
No. of stems ..	10				13				9			
Circumference of stem.	3¾ inches				3 inches				3¼ inches			

Table IV.

Comparison of Root Distribution Data for Two Different Stages of Growth of Uba Canes in Light Soil (Waterloo Estates).

(Percentages of Total Root Weights).

	Experiment VI.				Experiment VII.			
UBA.	PLANT CANES.				SECOND RATOONS.			
Columns	54	25	21		49	29	22	
Layers (4)	51	32	14	3	65	19	9	7
Total root weight	1377 cgm.				1306 cgm.			
Average Stool.								
Weight of stems	14.4 lb.				10.7 lb.			
Height	96 inches				85 inches			
No. of stems	15				17			
Circumference of stem ..	2½ inches				2½ inches			

The roots of ratoon canes appear to be much more superficial than those of plant canes, about one-half their weight occurring in the first 6-inch layer of soil, and nearly one-half occurring in the vertical soil zone immediately surrounding the stool. The total weight of root material appears to decrease in the three stages of growth. The average weight of a stool of cane stems also similarly, but much more markedly, decreases (actual measurements, 1.84, 13.1 and 8.3 lb.).

Experiments VI and VII. (Uba; Age, 9 to 12 months, Light Soil).

Plants *versus* Second Ratoons (Uba).

These paired experiments were exactly similar to the last, so that their results may be mutually compared, *i.e.*, the root distribution of BH 10/12 and of Uba in similar soil may be contrasted. Percentage data for Experiments VI and VII are presented in Table IV, and in Diagrams VI and VII.

CONCLUSIONS.

In this particular soil (Exchange Section; Index of Texture 24-25), Uba seems to develop a more superficial root-system than BH 10/12, but its superficial spread is also more pronounced in the ratoon stages. The difference in total root weight between plant-cane and second ratoons is apparently not so great in Uba as in BH 10/12 (1377/1306 against 1119/908=1.05 against 1.23).

The average stool-stem weight for ratoon Uba was slightly greater, however, than that for plant-cane Uba (15.7 lb. against 14.4 lb). Evidently Uba grows better in this type of soil under the practised methods of cultivation, than does BH 10/12.

SERIES B.—USINE STE. MADELEINE ESTATE, TRINIDAD.

Experiments VIII to XIII.

The main soil-types of this area are (1) a heavy, shallow, stiff, pale-red acidic soil, derived from Red-Weathering Clay (mottled blue-grey below); and (2) a heavy, fairly deep, friable, black alkaline soil, derived from cream-coloured, soft, calcareous marl (Princestown Marl). The second type is regarded as perhaps the best sugar-cane soil in Trinidad.

In the root-distribution studies in this area, the depth of sampling was 36 inches, (six 6-inch layers), otherwise the procedure followed was identical with that previously described (Series A).

Experiments VIII, IX and X. (Uba. Age 9-12 months, Heavy Pale-Red Soil.)

Plants *versus* Ratoons (Uba).

The results obtained in these three experiments with Uba Cane on heavy pale-red soil (Table V) may be compared with those obtained in the last two experiments with Uba on light alluvial soil (Table IV). To render comparison easier, the results of these three experiments have been recalculated for four 6-inch layers instead of six; the corrected results are also presented in Table V, along with the original results, and in Diagrams VIII, IX and X, by dotted lines.

CONCLUSIONS.

The marked superficial spread of Uba roots, as compared with those of BH 10/12, is again demonstrated, even though the cane is growing on much heavier soil (Index of Texture, 42 to 49). Its still more pronounced superficial spread in the ratoon stages is also demonstrated for the heavy soil. On the whole, penetration is not any less shallow in the heavy soil than in the light.

The total weights of root material are considerably greater for Uba growing on the heavy soil than for Uba growing on light soil, but the proportionate weights of roots for plants, first ratoons and second ratoons varies very little (1885, 1701, 2178 cgm., respectively). (A similar relationship was also demonstrated for the light soil.)

The average stool-stem weight for Uba plant canes was much greater in the heavy pale-red soil than in the light alluvial soil (21.1 against 14.4 lb.), but was only a little greater in the ratoon stages (11.8 against 10.7 lb.).

Experiments XI, XII and XIII (BH 10/12. Age, 12-13 months).

Heavy black marl soil *versus* Heavy pale-red soil.

The results obtained in these experiments may severally be compared with those of the last three experiments, as well as between themselves. The data are presented in Table VI and in Diagrams XI, XII and XIII.

CONCLUSIONS.

As in previous comparisons, the root distribution of BH 10/12 canes, both plant-canes and first ratoons, is less confined to the surface layer than that of Uba canes, and differs but slightly in the two contrasted kinds of soil, both of which, however, are heavy in texture, particularly the surface soil.

The total weights of roots again are considerably less for BH 10/12 than for Uba, even though the average stool-stem weights, particularly for plant canes, are larger.

Table V.

Comparison of Root Distribution Data for Three Different Stages of Growth of Uba Canes in Heavy Pale-Red Soil (U.S.M. Estates).

(*Percentages of Total Root Weights*).

UBA.	Experiment VIII. PLANT CANES.	Experiment IX. FIRST RATOONS.	Experiment X. OLD RATOONS.
Columns	40 29 31	53 26 21	48 27 25
Layers (6)	36 28 14 8 7 7	33 28 16 9 8 6	57 15 8 7 7 6
Total root weight ..	1885 cgm.	1701 cgm.	2178 cgm.
Results recalculated for four 6-inch layers.			
UBA.	PLANT CANES.	FIRST RATOONS.	OLD RATOONS.
Columns	40 29 31	55 26 19	53 25 22
Layers (4)	42 33 16 9	38 32 19 11	65 18 9 8
Total root weight ..	1636 cgm.	1447 cgm.	1910 cgm.
Average Stool.			
Weight of stems ..	21.2 lb.	30.8 lb.	11.8 lb.
Height	132 inches	96 inches	84 inche
No. of stems	16	22	14
Circumference of stem	2½ inches	3 inches	2½ inches

Table VI.

Comparison of Root Distribution Data for Two Very Different Soil Types, BH 10/12 Canes (U. S. M. Estates).

(*Percentages of Total Root Weights*).

BH 10/12.	Experiment XI. BLACK MARL SOIL PLANT CANES.	Experiment XII. PALE RED SOIL FIRST RATOONS.	Experiment XIII. BLACK MARL SOIL FIRST RATOONS.
Columns	50 28 22	47 30 23	51 28 21
Layers (6)	33 20 17 11 10 9	36 21 14 10 11 8	35 24 13 10 11 7
Total root weight ..	1189 cgm.	1512 cgm.	843 cgm.
Average Stool.			
Weight of stems ..	65.3 lb.	25.1 lb	34.8 lb.
Height	132 inches	96 inches	120 inches
No. of stems ..	13	10	9
Circumference of stem	5 inches	4 inches	4 inches

Table VII.

Comparison of Root Distribution Data for Three Very Different Soil Types; BH 10 12 Plant Canes. (Caroni Estates; I.C.T.A.)

(Percentages of Total Root Weights).

BH 10/12.	Experiment XIV. Heavy Acidic Soil Plant Canes.	Experiment XV. Light Neutral Soil Plant Canes.	Experiment XVI. Very Light Neutral Soil. Plant Canes.
Columns—Small Roots ..	19 10 5	18 8 7	19 15 13
Large Roots ..	25 20 21	26 23 18	27 16 10
Layers (6) Small Roots ..	30 14 6 7 5 6	24 14 8 6 8 6	10 12 9 8 4 4
Large Roots ..	11 11 3 3 2 2	9 8 5 3 5 4	18 14 10 7 2 2
Total root weight ..	670 cgm.	716 cgm.	1350 cgm.
Average Stool.			
Weight of stems ..	6.6 lb.	17.4 lb.	—
Height	54 inches	84 inches	—
No. of stems ..	6	10	—
Circumference of stem ..	3½ inches	4½ inches	—

Series C.—Caroni Estates, Trinidad.

Experiments XIV and XV.

Imperial College of Tropical Agriculture.

Experiment XVI.

The soils of the Caroni area are mainly derived from Swamp and Lagoon Alluvium, and from Recent River Alluvium, that has been superimposed upon it during periods of flood by present-day rivers. The soils of the College Farm are mainly derived from sandy detritus or hill-wash from the Northern Range, whose rocks are chiefly quartz-schist.

In this series, three different types of soil were compared as regards root distribution of BH 10/12 plant canes. The first soil-type (Expt. XIV) is heavy, acidic, Swamp and Lagoon Alluvial grey soil; the second (Expt. XV) light, sandy, slightly calcareous, Recent River Alluvial grey soil, and the third (Expt. XVI), detrital, reddish-brown soil, of the College Farm. The depth of sampling in each case was 36 inches, and the root samples in these particular experiments were severally divided into large roots and small roots.

The results obtained are presented in Table VII, and in Diagrams XIV, XV and XVI.

Conclusions.

The distribution of roots of plant-canes in detritus soil (Expt. XVI) may be regarded as nearly ideal (Diagram XVI). The crop was exceptionally heavy, although the stool-stem weight was not determined. The data show that the weight of small (absorbing) roots was only slightly less than that of large roots in this soil-type.

Root distribution in the other two soil-types was somewhat different: it was more superficial in the heavier soil than in the light, especially for small roots. The total root weight was very nearly the same for the two kinds of soil, although the stool-stem weight was almost three times as great for the light-soil as for the heavy-soil canes. (The actual yields per acre on reaping were 22½ tons per acre for the light (good) soil, and only 7⅓ tons per acre for the heavy (poor) soil.)

Experiments XIV and XV afford interesting information regarding the effect of fluctuating ground water on the vertical distribution of cane-roots in the soil. At each site, the appearance of the soil profile was described in detail, and representative soil samples from the different horizons were analysed in the laboratory for various soil constants, including degree of acidity. Furthermore, periodic measurements of the fluctuations of ground-water level were made within the two regions, by means of sunken perforated tubes. The results obtained have elsewhere been presented and discussed by the writer (2). The effect of fluctuating ground water may be clearly traced in the soil profile; the distribution of cane-roots appears to be largely controlled by these fluctuations. Thus, the surface "zone of non-saturation" in the light sandy (good) soil is considerably wider than that in the heavy (poor) soil (26 against 18 inches), but, in each case, three-quarters of the total root weight were found to occur in this zone, so that the range of root distribution is greater in the light, good soil than in the heavy, poor soil. A rather sudden increase in the amount of root material occurs at the top of the next (mottled) "zone of intermittent saturation", suggesting a response to the greater degree of moistness in this layer.

The blue-grey "zone of permanent saturation", in which aeration is lacking, coincides with the dry-season mean level of ground-water; its depth below the soil surface is greater in the light, good soil than in the heavy, poor soil (44 against 37 inches); few roots penetrate into this permanently-wet zone.

(IV).—Summary.

(1) Root distribution has been quantitatively examined in Trinidad for two varieties of sugar-cane (BH 10/12 and Uba), in contrasted kinds of soil (light and heavy), for different stages of growth (plants and ratoons).

(2) The method employed consisted in the collection of soil-cores from successive 6-inch depth-layers down to two or three feet, along a single radius at three intervals, for five similar cane-stools. The root contents of the cores (60 or 90 in number, for each experiment) were separated by soaking and wet-sieving, and their dry weights were determined for comparison. In one experiment, large roots were separated from small roots by hand-picking.

(3) The data obtained indicate that :—

(*a*) there appears to be no simple relationship between root-weight and crop-weight (stool-stem weight) of sugar-cane growing in Trinidad.

(*b*) roots of ratoon canes are more superficial than roots of plant-canes in Trinidad.

(*c*) roots of Uba canes growing in Trinidad are generally more superficial than those of BH 10/12 canes of the same stage of growth (plants, first ratoons, second ratoons).

(*d*) the effect of soil texture is not very marked; the weight of roots produced in heavy soil tends to be somewhat greater than that produced in light soil in Trinidad.

(4) Vertical root distribution appears to be controlled by fluctuations in ground water level, which impress certain distinctive features on the soil-profile, and may be estimated by soil-profile examination.

References.

(1) Hardy, F.—An Index of Soil Texture. *Journ. Agric. Sci.*, 1928, XVIII, p. 252.

(2) Hardy, F.—The Ecological Significance of the Soil Profile. *Proc. Internat. Soc. Sugar-Cane Technol.*, Puerto Rico, 1932, Bul. 64.

(3) Hardy, F., and Steven, R. M.—Study of Cane-Root Distribution. *Proc. Froghopper Invest. Cttee.*, 1927, I, p. 317. Trinidad.

(4) Jensen, J. H.—Some Studies of Root Habits of Sugar-Cane in Cuba. *Sci. Contrib.* 21, 1931, *Trop. Res. Foundn.* New York.

(5) Lee, Atherton H.—The Distribution of the Roots of Sugar-Cane in the Soil in the Hawaiian Islands.—*Plant. Physiol.*, 1926, I, p. 363.

(6) Mauer, F. M.—Study of the Root System of the Cotton Plant. *Repts. Turkestan Plant Breeding Sta.* Tashkent; Emp. Cotton Growing Corp., London, 1925-27.

(7) Roxas, M. L., and Villano, M.—Studies on the Development of the Sugar-Cane Plant in the Philippines. *Philipp. Journ. Sci.*, 1930, 43, 3, p. 367.

(8) Weaver, J. E.—Root Development in the Grassland Formation. *Carnegie Inst. Wash.* 1920., and other monographs.

(9) Venkatraman, R. T. S.—Studies of Sugar-Cane Roots at Different Stages of Growth. *Mem. Dept. Agric. India.* 1929, XVI, p. 145.

(10) Venkatraman, R. T. S., and Thomas, R.—Sugar-Cane Root Systems: Studies in Development and Anatomy. *Agric. Journ. India.* 1922, XVII, p. 381.

(11) Weller, D. M.—Some Effects of Sub-Soil Fertilization on the Tops and Root System of H-109 Cane. *Repts. Assoc. Hawaiian Sugar Technol.*, 7th Ann. Meeting, 1928, p. 93.

(12) Wolters, W.—The Effect of Fertilizer on Root Distribution. *Repts. Assoc. Hawaiian Sugar Technol.*, 8th Ann. Meeting, 1929, p. 141.

PLANT DISEASE AND ENVIRONMENT IN SOUTHERN RHODESIA.

By J. C. F. Hopkins, B.Sc., A.I.C.T.A.,
Government Plant Pathologist.

Introduction.

The study of the relationship between environment and phytopathology is to-day receiving more attention from mycologists throughout the world; the recent developments in agricultural meteorology helping in large measure to focus attention upon the subject. Whilst meteorological factors are of leading importance in influencing the phytopathological complex of a country, yet it must be borne in mind that biotic and edaphic factors take a prominent place in controlling the parasite population of any particular area. Habitat and climate are so closely connected in their effect upon plant disease, that it is difficult to know where to place the limit of influence of either. Biotic factors are likewise frequently correlated with climatic, as in the influence of temperature and humidity upon the prevalence of insect vectors or indigenous host plants, but there is one biotic factor, which is only indirectly affected by meteorological conditions and which rarely receives the attention it deserves in mycological literature and that is the human population—particularly the civilised races. This often becomes the limiting factor in the control of plant disease, for upon the attitude of the population towards this problem depends the success or failure of recognised measures which may be instituted by the local phytopathological service. This matter will be considered later. Before discussing the effects of environment on plant diseases in Rhodesia, it will be as well to detail shortly the component parts of this environment. They have been discussed and illustrated with maps by Henkel (1).

Factors Influencing Disease.

Climatic.

With regard to rainfall, the climate of Southern Rhodesia may be conveniently described under three categories: (*a*) a short and moderate wet season commencing in October and continuing until the end of April, (*b*) a dry season for the

remaining months of the year, and (*c*) intermittent periods of drought, varying in length of time, which may occur between the middle of December and March. The time of incidence and duration of these dry spells have a marked influence on both the incidence and development of plant diseases, although it is their effect upon development which is usually most striking.

The early rains arrive characteristically in the form of thunderstorms, becoming more general as the season advances. About one-third of Southern Rhodesia has a rainfall of between 30 and 40 inches, but some of the eastern mountain areas receive over 40 inches and approximate to a "mist belt"; a further third of the Colony lies between the 25 and 30 inch isohyets, whilst the remaining third receives below 25 inches. In most parts of the Colony little or no precipitation occurs during the dry season, but on the eastern border from three to five inches may be recorded for the whole of the six months, and this occurs chiefly as mists. The seasons are erratic, and wide fluctuations in the annual rainfall are experienced in all districts. This seasonal eccentricity is reflected in the behaviour of the diseases of most crops, and is the indirect cause of several non-parasitic disorders induced by physiological disturbances in the plant.

Temperatures, which are dependent upon geographical situation, are also considerably influenced by the topography of the country, of which about 24 per cent. is over 4,000 feet elevation, for it is found that over the greater part of the territory the mean shade temperatures are from 10 to 15°F. lower than at sea level in the same latitudes. Thus, although the greater part of Southern Rhodesia lies between latitudes 16° and 22°S., *i.e.*, within the tropics, yet 66 per cent. falls within the mean annual temperature range of 60-72°F. (2) and is found to be suitable for European settlement. The phytopathological considerations of an economic nature in this Colony are chiefly concerned with conditions prevailing amongst a settled community, so that the influence of temperature on plant diseases is controlled principally by the limits of temperature found within the settled areas. The upper limit of these annual mean temperatures agrees almost exactly with a 3,000 feet elevation, where conditions are distinctly tropical, whilst the lower limit embraces altitudes of 5,000 feet or over, which are suitable for the cultivation of temperate crops such as deciduous fruits and small cereals. Even so, both tropical and temperate crops may be grown fairly successfully within the limits stated, so that a wide range of conditions has to be surveyed in the ecological study of any one disease or crop plant.

Edaphic.

Just as climate affects both directly and indirectly the incidence of plant disease, so does soil play its part in the plant pathological complex. Rhodesian soils, from the agricultural point of view, may roughly be classified into two main types, namely: (*a*) granite, and (*b*) red clay soil of basalt and dolerite formation. Rocks of the granite formation occupy 49.5 per cent. of the total area of the country whilst basalt and dolerite are confined to 5.1 per cent. The latter are regarded as of high fertility and have been instrumental in attracting European immigrants from the time of the occupation of the territory; so that one finds well established and populous agricultural communities occupying relatively small areas where more or less intensive cultivation is in progress. Maize is the principal crop grown in these areas, and the problem of control of its diseases is intensified by close settlement.

The granite soil or sand-veld, on the other hand, is of wide distribution and is comparatively unfertile, and it was not until flue-cured tobacco culture obtained popularity in recent years that its agricultural possibilities attracted many settlers. Despite the huge area of this type of soil which is available for farming, only a relatively small acreage is tilled, and this by fairly closely settled communities of recently arrived growers. There are, however, certain districts on the sand-veld where close settlement by Afrikander farmers has taken place, but these areas are not intimately concerned with plant disease problems owing to the pastoral pursuits of the inhabitants. It is the flue-cured tobacco districts which offer an interesting study in environmental effects.

Biotic.

As with other countries, the local flora and fauna are principally controlled by meteorological conditions and are to a large extent dependent upon each other. Their relationship to plant diseases is chiefly as host plants and insect vectors, although certain indigenous plants are themselves parasitic, whilst insects facilitate infection by causing mechanical injury to plants and assist in the dissemination of fungus spores and bacteria. The higher wild animals, with the exception of birds, do not appear to be closely correlated with plant disease, but domestic beasts, particularly cattle, are an outstanding feature in the local life cycle of *Diplodia zeae* on maize, and are the cause of certain practices in pasture management for the control of ergot.

With regard to the human factor the agriculturally effective population divides itself into native and European; the former exerting its influence upon local diseases only as regards crops which are common to both races, and in relation to its utilisation for labour. The white races, on the other hand, have a direct bearing upon local phytopathology, whether the individuals be actively engaged in the growing of crops or merely connected with agriculture through the economic channels of commerce.

Southern Rhodesia is a country of great distances and small population, several miles usually separating rural families from each other. Large farms of 1,000 acres and upwards are the vogue, and the crops grown, *i.e.*, maize, tobacco, cotton, &c., are planted over extensive acreages. There is nearly always a considerable distance separating the farmer from his local market, and facilities for marketing are not such that the grower takes much heed of small change. Furthermore the constant struggle with untamed Nature, coupled with isolation, has induced a fatalistic attitude of mind which makes the grower content to obtain any reasonable measure of profit from his labour, and he is loth to embark upon enterprises in plant disease control, which, even now, are regarded by some with a kind of superstitious suspicion. A factor militating against the use of fungicidal sprays is the large area of land planted to any crop, necessitating as it does the use of large mechanical appliances beyond the means of the average farmer. If to this is added the fact that a bumper crop from one farm may have the effect of swamping the local market and rendering the produce unsaleable, then the cautious, and to the plant pathologist, often exasperating attitude of some growers, is fully explicable.

On the other hand, when some operation, especially if it can be performed by native labour, is found to give obviously beneficial results, then its rapid adoption may be assured, as is instanced by the almost universal treatment of tobacco seed before sowing, and the use of Bordeaux spray on the seed-beds. In such cases, the presence of a superior type of white farmer throughout the colony ensures the success of counter disease measures. It is, however, characteristic of young and democratic countries that any form of so-called Government interference is strongly resented, and any attempt at legislation for the internal control of plant diseases is therefore fraught with difficulty. This is where the plant pathological position in a colony such as Southern Rhodesia differs from that in, say, a native protectorate. Whereas in the latter, the promulgation of legislation for the destruction of crops to prevent the spread of a dangerous disease is a comparatively simple matter, yet the introduction of such legislation into Southern Rhodesia would be opposed from many quarters, for every man has a right to his own views. On the other hand, should the legislation meet with approval, then active co-operation could be expected from the white community and a large measure of success in the control of the disease could be obtained: this would be difficult in the extreme amongst a native community where the complete enforcement of such legislation is almost an impossibility, with the staffs usually available, as anyone who has tried it knows. It would therefore appear that the possibility of plant disease control by legislation is more favourable amongst a white community than under the conditions obtaining in a native protectorate, and since close settlement and rapid transport facilitate the spread of disease, the natural barrier of bush typical of native cultivation in Africa being absent, it would seem that, when the occasion arises, some form of legislation will provide the best means of staying the progress into Rhodesia of an invading parasite.

In other lands, the relationship between the human population and plant disease varies with geographical and racial conditions, so that the reaction of phytopathology to Man should not, as is usually the case, be regarded solely as a function of economics. Without his presence, there would be no agriculture but plant diseases would exist notwithstanding. Variations in the mycological microcosm resulting from the production of cultivated plants are thus directly due to the influence of Man, for the relationship between plant diseases and agriculture is very largely determined by the nature of the human population, which must therefore be treated as an ecological factor when investigating an epidemic or formulating control measures. Phytopathological reactions resulting from the behaviour of the human population may be as varied as those caused by soil or climate, for, in an endeavour to produce commercially a crop unsuited to the chosen habitat, undue strain may be placed upon the adaptability of the plant thus rendering it susceptible to diseases to which it is normally resistant.

This necessarily brief survey of the factors influencing plant diseases in Southern Rhodesia, should serve to acquaint the reader with the general conditions existing in the Colony so that the reactions of the different crops to their environment can be the better visualised. Because the consideration of all the forces, both biological and physical, exerted upon a crop during its period of growth is largely a matter of speculation, it will be as well to take a few concrete examples of selected crops, the etiology of whose diseases is sufficiently well known, and to discuss the effect of the Rhodesian environment upon the incidence and development of certain of these diseases.

Diseases.

The principal diseases of tobacco in Rhodesia are largely influenced by climatic variations, but certain affections depend upon soil conditions for their development, whilst others are closely linked with the habits and methods of the European grower and native labourer. Nearly all are intimately associated with the personality of the farmer who is producing the crop.

Probably the most potentially dangerous disease so far experienced is wildfire (*Bacterium tabacum*), which appears to be entirely dependent upon favourable weather conditions for its development. In a less obvious manner, angular spot (*Bacterium angulatum*) is similarly controlled. Both diseases

may make their appearance in the early stages of cultivation, but may never become of economic importance unless certain conditions are fulfilled. As is generally known, these bacterial diseases require cool, humid weather for infection to take place, whilst driving rains are necessary for their dissemination. Given such a favourable environment, it is not unknown for wildfire to sweep through and destroy fields of 60 or more acres within a space of three days. The spread of angular spot may be almost as rapid, particularly if a field of half-grown tobacco is subjected to the buffeting of a heavy storm, but generally speaking, although more prevalent, angular spot appears to be kept under reasonable control by normal weather conditions, and is often entirely checked in its development by a mid-season spell of hot, dry weather. Such conditions also prevent the development of wildfire, but a subsequent period of favourable weather generally initiates a further outbreak, which may entirely ruin a crop unless another short period of dry weather follows, hastening the ripening of the plants and, consequently, harvesting.

Both these bacterial diseases are known to be seed-borne and to a large extent successful control depends upon efficient disinfection of seed. Among European settlers there are still some who disagree with the principle of seed treatment, whilst others perform the operation indifferently, so that outbreaks of wildfire on as many as 16 farms in different parts of the country have been traced to one lot of imperfectly treated seed. Here again the human element is involved, and so long as treatment of seed is dependent upon the eccentricity of the individual, the control of these bacterial diseases can never be complete.

Other factors, of course, play a part in their perpetuation, in particular, climatic conditions prevailing during the winter months, the farm methods employed by many growers, and the habits of native labourers. To deal first with climate, it will be remembered that the normal dry season in Rhodesia lasts for 6 months, from April to October, when no rain whatever falls over the greater part of the territory. It is understandable therefore that as the remains of crops, in order to rot down completely, must be ploughed in whilst there is ample moisture in the soil, there is little hope of tobacco stalks and similar trash becoming disintegrated before the planting of the succeeding crop, since reaping is not finished before the middle of April at the earliest. Much of this undecomposed trash is heavily infected by disease, and remains as a source of infection for the following year. Fungus diseases, particularly Alternaria spot (*A. tabacina* (Ell. and Ev.) Hori. emend Hopkins.) and frog eye (*Cercospora nicotianae*), are also harboured in infected trash, and may remain in fallow lands throughout the winter to initiate an outbreak of disease in the following season.

Many growers make no attempt to clear up crop remains until just before the land is required for planting again. In some cases, where the field is to be left fallow, little or no attempt is made to eradicate volunteer plants which grow from old stalks or dropped seed. They are, as a rule, completely hidden by the vegetation which springs up when night temperatures begin to rise, and, being out of sight, are also conveniently out of mind. Such abandoned stalks invariably give rise to "suckers", which are infected with parasitic and virus diseases, and there is little doubt that infections in the seed-beds can be traced to the native snuff and chewing tobacco, which is made almost entirely from air-dried "sucker" leaves. Furthermore, it has recently been demonstrated that the white fly vector of the newly described tobacco leaf curl (3) breeds upon the early spring growth of volunteer plants, which are very often infected by the virus, and transmit the disease in severe form to the first plantings of the new crop. It will therefore be seen that, as far as tobacco is concerned, the human factor, both European and native, plays an equally prominent part in the initiation of outbreaks of disease as does the climate, upon which the blame is usually placed.

The prolonged dry season in Rhodesia is responsible for the perpetuation of many diseases of plants, owing to the failure of infected material to rot rapidly away. Winter temperatures are not sufficiently low to cause the death of pathogenic organisms, so that the onus for the eradication of pests lies upon the farmer himself, who must take the initiative and not depend upon the forces of Nature alone.

The Dry Rot of maize, due to *Diplodia zeae*, offers an interesting example of the complexity introduced by the long dry season. The life-cycle of the fungus is essentially the same in this Colony as elsewhere, that is, infection of the cob is brought about by wind-borne spores which alight upon the "silks," the leaf sheath, or other parts of the plant. They germinate under favourable conditions and produce a mycelium, which penetrates to the kernels by devious routes and establishes an infection of seed for the following year. The mycelium also penetrates the stalk giving rise to pycnidia at the nodes, after the plant has matured. Two sources of infection for succeeding crops are therefore established, one in the seed, the other in old stalks and cobs, which are allowed to remain in the lands. It would appear at first sight to be a simple matter to eradicate such a disease, for seed selection and disinfection, on the one hand, and destruction of maize trash by ploughing, on the other, should theoretically reduce infection to negligible proportions. Unfortunately, under Rhodesian conditions, it is not practicable for the average farmer to plough in his trash whilst the soil still contains sufficient moisture to enable the implements to work efficiently, because the maize stover is

required to supplement the very meagre range feed which is available for his working cattle. If these are allowed to get into poor condition, the maize grower is deprived of draught animals for riding his crop to the railway and is unable to prepare his lands in time for planting with the first rains. The residue of the maize crop is therefore either left standing, or else stooked, in the lands to be fed down at will by the cattle. Other methods of feeding will occur to the reader, but nothing has so far been evolved which will not add to the cost of production of the crop.

Seed selection by the farmer cannot be regarded as a reliable control measure, for it is certain that wherever in the world seed-borne diseases occur, a fair proportion of infected kernels is contained in farm selected seed. In Rhodesia, where seed is of good quality, a relatively high percentage of contamination by *Diplodia zeae* (and also *Giberella saubinettii*) exists, and under certain conditions, such as prolonged cold, wet weather or light rains followed by drought, seedling blight may seriously reduce the field stand. Seed selection, therefore, needs to be supplemented by seed disinfection in order to protect the young plants from the vagaries of climate. But such protection is only temporary and has not been found to influence the amount of cob infection which develops each year.

It has been pointed out that spores of ear-rotting fungi are to be found in undecomposed plant remains in many maize lands, and the presence of these spores gives rise to early infection of the leaf sheaths of the young plants, resulting in the ultimate production upon the stalks of further pycnidia at the end of the season. Furthermore, wind-borne spores are responsible for a large proportion of cob infection by way of the "silks," and it is found that when frequent light rains and moderate temperatures occur at the time of pollination, resulting in a large number of well filled cobs, then the proportion of *Diplodia* infection is relatively high. When unfavourable conditions for fertilisation are experienced, such as hot, dry periods, then the amount of *Diplodia* in the harvested crop is low. Thus, under normal conditions, a big maize crop means a big crop of *Diplodia*, and *vice versa*, largely depending upon weather conditions at the time of pollination. Contrary to expectations, it has been found that late rains occurring in March or April, when the cobs are well developed, do not appreciably increase the number of diseased cobs reaped, although delayed drying appears to cause a more severe infection of the individual ear. In many cases, the fungus penetrates a considerable distance down the core, infecting the butts of the kernels, often with no visible discolouration. Seed may be selected from such cobs and is the cause of severe seedling blight in the early stands of young plants.

Other seed-borne organisms are responsible for the deaths of seedlings, in particular *Giberella saubinettii*, *Rhizopus stolonifer*, and a green *Aspergillus* must be mentioned. It has been observed that the activity of these fungi is largely controlled by rainfall and temperature. For instance, when ample rains, interspersed by bright periods, are experienced, then germination of seed is rapid resulting in a high percentage of vigorous plants; if, however, periods of warm sunshine are scarce and temperatures are low, then a damping off of young plants is brought about by *R. stolonifer* and *G. saubinettii*. Conversely, when rains are light and temperatures high, then the slowly germinating seedling is attacked by *Aspergillus*, which may do quite a lot of damage. With the sudden advent of good growing weather, however, it is usually found that the *Aspergillus* infection is insufficient to affect the crop appreciably.

These observations are based upon pot experiments and the examination of field material.

Diseases of cotton appear to be very largely controlled by the climatic conditions prevailing in the Colony. They have been dealt with more fully elsewhere (4), but a few notes may be of interest to the reader. Generally speaking, the crop receives good rains and warm temperatures for a few months, after which the rains cease relatively suddenly and temperatures drop considerably. Such conditions favour the development of fungus and bacterial diseases in the early part of the season, so that angular spot (*Bacterium malvacearum*) and fungus leaf spots are commonly present. Before these can cause any really serious damage, however, climatic conditions unfavourable to their development intervene and the diseases are arrested. Thus the serious "black arm" is not encountered and the amount of internal boll disease (*Nematospora coryli*) is not as a rule proportionate to the number of "stainers" found in the cotton fields. Similarly, boll rots due to *B. malvacearum* and *Rhizopus stolonifer* do not develop to the same extent as in more humid countries, and other boll rots are rare; root diseases due to fungi are unknown. It therefore appears that diseases of cotton in Rhodesia are controlled at present solely by climatic factors.

It has been shown that the long dry season is detrimental to the efficient control of a number of crop diseases but, on the other hand, it holds in check infections which render summer cultivation of certain crops impracticable. Small cereals in particular are included in this class. So far, no commercial rust-resistant summer wheat has been evolved in the Colony, yet good yields are obtained in many parts with irrigated winter crops. Similarly, in the eastern districts, excellent barley is grown, which appears to be unaffected by rusts. Although seed treatment is not extensively employed, yet no reports have been received of severe smut infection, nor have *Helminthosporium* diseases made their appearance, despite their prevalence in the Union, which exports seed to this colony. The low atmospheric humidity and temperatures during the winter

months are undoubtedly responsible for this freedom from disease, for where endeavours have been made to grow small cereals in an unsuitable environment, failure has resulted from rust infection, and, in a single recorded case, root-rot due to *Helminthosporium sativum*, on wheat.

Potatoes also are grown almost free from disease during the winter, but are extremely susceptible to early blight (*Alternaria solani*) when atmospheric humidity is high, so much so that the acre yield is often reduced by half unless fungicides are employed. Reports have been received of good crops of clean tubers being produced during the winter on irrigated land, which was so heavily infested by eelworm (*Heterodera radicicola*) as to render it useless during the summer.

Market gardening is also facilitated by the low temperatures of winter, and controlled water. In some parts it is not possible to grow successfully during the rainy season certain vegetables, owing to attacks of fungi. Carrots may be completely destroyed by leaf blight (*Alternaria circinans*) and most varieties of peas are severely attacked by mildew (*Erysiphe polygoni*). Neither of these diseases appears during the cool weather. Owing to their susceptibility to frost, however, tomatoes are only raised with difficulty during the winter at the higher elevations, so that there is usually a shortage in the larger towns during October and November, and high prices are paid for good fruit. A number of growers find tomato cultivation a profitable sideline during the dry season and endeavour to overcome climatic deficiencies by means of grass shelters and artificial watering. The intense transpiration which is caused in the plant by the very dry atmosphere (the relative humidity may be as low as 23), and the rapid evaporation which takes place from the soil, calls for much attention and care in watering; and where water is withheld as a result of carelessness on the part of the native gardener or for any other reason, it is found that the tomato plants become affected by blossom-end rot. The same disease also develops when water is applied constantly and in excess, despite the fact that tomatoes grow luxuriantly during the rainy season. Many other instances could be quoted of disease resulting from attempts to grow crops in unsuitable environments.

Climate is thus the predominating influence in the phytopathological complex of Rhodesia, but its effects are not always direct, for bound up with climatic factors are those of the human population and the problem of adaptability, or "tolerance", in agricultural plants. The rural population endeavours to grow crops suitable for export, in order to supply the needs of Man in entirely different parts of the World, and, in doing so, frequently chooses crops which are not the most suitable for cultivation in its own environment. In the same way it endeavours to grow for local sale food crops which are demanded by a population existing in an artificial environment maintained as nearly as possible to that of the Mother country. Numbers of such crops yield some sort of financial profit, but the Colony has not been settled sufficiently long for the European grower to have evolved strains of his traditional food plants suitable for cultivation locally or for his tastes to have adapted themselves to local produce. It is a moot point as to which possesses the least degree of adaptability, the body of the plant or the mind of Man.

References.

1. Henkel, J. S.—Types of Vegetation in Southern Rhodesia. *Proc. Rhodesia Scient. Assoc.*, Vol. XXX, 1931.
2. Henkel, J. S.—*Official Year Book of the Colony of Southern Rhodesia*, No. 2, 1930.
3. Storey, H. H.—A New Disease of the Tobacco Plant. *Nature*, Vol. CXXVIII, No. 3222, 1931.
4. Hopkins, J. C. F.—Some Diseases of Cotton in Southern Rhodesia. *Empire Cotton Growing Review*, Vol. IX, 2, 1932.

TOP WORKING OLD COFFEE TREES.

In an experiment recorded in the *Philippine Agriculturist*, Vol. XXI, 1932, 137 low yielding *Coffea robusta* trees were cut back to from 60-90 cm. above the ground. Of the shoots which subsequently grew from these stumps (in 18-40 days) three or four were allowed to remain and were cleft grafted when fit (in about 250 days). The scions used were taken only from main stems and were (*a*) young and green or (*b*) older with woody stems. The covering material used was either glass tube (30.8 per cent. success), sphagnum moss (8.4 per cent. success) or banana leaf petiole (4.8 per cent. success), the two last being moistened or changed respectively when necessary. Grafts with no covering beyond grafting tape gave 21.8 per cent. success. The old woody scions gave 37.8 per cent. success, the young green scions 14.1 per cent. The size of stock or of scion did not appear to have any direct relation to the success of the grafting.—(*Horticultural Abstracts*, Vol. III, No. 1.)

REPRINTS.

The following reprints of articles which have appeared in the Journal can be obtained on application to the Editor :—

Banana Fruit Diseases	C. W. Wardlaw	6*d.*
Bananas in Storage and Transport	C. W. Wardlaw and L. P. McGuire	6*d.*
Fruit and Vegetable Storage	L. P. McGuire	6*d.*
Panama Disease Research	C. W. Wardlaw	4*d.*
Soils and Flora	C. W. Wardlaw	6*d.*
Cacao Research	W. G. Freeman	6*d.*
Early Maturity in Cotton	S. C. Harland	2*d.*
Limes and Withertip	R. O. Williams	6*d.*
Trinidad Cotton Research Station	S. C. Harland	6*d.*
Rationalisation (Pts. I-V)	H. M. Leake	6*d.*
Labour Efficiency	E. A. Seagar	6*d.*
Defective Diet	E. A. Seagar	6*d.*
Parasitology in the Tropics	T. W. M. Cameron	4*d.*

REVIEWS.

An Introduction to Plant Physiology.

By W. O. James. *Clarendon Press*, Oxford, 1933, Second Edition. pp. 263, price 7*s*. 6*d*.

This book is written to senior school or junior university standard, and seeks to give a balanced account of the more elementary aspects of the subject. The chapter headings include (1) Material and Energy; (2) Sugars and Plant Materials formed from them; (3) Nitrogenous Compounds; (4) Decomposition of Sugars; (5) The Protoplast; (6) Water; (7) Irritability; and (8) Growth (germination, development, reproduction). There are numerous clear diagrams, and a section dealing with experimental work concludes each chapter. More than one-half of the book is written from the view point of the biochemist, and stresses the great importance of plant function. This treatment conveys the idea that the plant body is a laboratory in which a great many chemical reactions and physical processes occur, but it may easily err in imparting an impression that all known plant phenomena may simply be explained in terms of established elementary principles, whereas actually little is really known about the mechanism of such processes as nutrient uptake, translocation and the various tropisms. In an introduction, such as this, to the vast domain of plant physiology, simplicity is doubtless a necessity, and in this respect Dr. James' book has much to recommend it. It is well written, well printed and attractively arranged; the experimental sections furnish a very useful guide to the study of the biochemical aspects of plant physiology.

F. H.

* * *

Soil Survey of Sierra Leone.

By F. J. Martin and H. C. Doyne. *Department of Agriculture*, Sierra Leone, 1931. pp. 26, with References, 8 pp. Tables, Geological Map and Soil Map.

"During the last few years, there has been an "increasing interest evinced in the properties of "soils of the various British colonies and "possessions, and the recent West African "Agricultural Conference (March, 1927) emphasized the necessity for collecting information "with respect to the soils of West Africa." This pamphlet presents a brief description of the climate, agriculture, geology and soil types of Sierra Leone; it provides a valuable contribution to knowledge of West African soils. A preliminary report on soil survey work carried out in Sierra Leone up to the end of 1925, was issued in 1926 by Dr. Martin; it was based on the laboratory examination of some 600 soil samples. Since 1926, some 900 further samples have been examined. Data appertaining to all these soils are tabulated in an appendix to the pamphlet. In most cases, the soils were sampled in profile to the four-foot depth.

Practically all the soils of Sierra Leone fall within the classes, "laterite soil" and "lateritic soil," as defined by the authors in terms of the molecular silica alumina ratio of the clay-fraction (1.33 or below for laterite soils, and 2.00 to 1.33 for lateritic soils). These soils are mainly derived from gneisses and schists, produced by metamorphosis of ancient sedimentary rocks, and of intruded and extruded igneous rocks of granite and gabbro-norite types. The soils are classified into (1) *Laterite Soils* (mainly derived from norite that forms hilly country, and supports a grassy or bushy vegetation), (2) *Lateritic Gravels* (widespread, and similar in appearance to the last), (3) *Red Sandy Soils* (occurring in hollows as hill-wash), (4) *Brown Sands and Sandy Loams* (of the coastal Pleistocene region mainly), (5) *Coarse Sandy Soils* (beach sands), (6) *Swamp Soils* (occurring in coastal, estuarine and interior depressed regions), and (7) *Black or Brown Grit Soils* (distributed in the Northern Province).

The texture of these soils is generally light (except some Swamp Soils), and water percolates rapidly through them. They are acidic (pH value 4 to 6), and show appreciable lime requirements. Organic matter content varies from 2.0 to 4.0 per cent. Potash and phosphate are generally markedly deficient, and exchangeable calcium seldom reaches 0.1 per cent., having been removed by leaching under the prevailing conditions of heavy rainfall (90 to 150 inches).

F. H.

* * *

Microbes and Ultramicrobes.

By A. D. Gardner. *Methuen & Co., Ltd.*, London. pp. 118, price 3*s*. 6*d*.

For students, this book is an excellent introduction to bacteriology, giving a skeleton round which the more complicated body of the subject may be built. It is divided into three parts: Part I deals with bacteria and their variation, including a short explanation of the different generic names as well as a detailed discussion of the occurrence of Rough and Smooth forms; Part II summarises our present knowledge of the viruses and their relation to immunity; and Part III is devoted to the bacteriophage phenomena. The author assumes little or no previous knowledge of the subject, and his style is very clear and concise. A glossary is appended in order to avoid laborious explanations of terms throughout the text. Research workers in other branches of science will also find the book interesting, as an appreciation of the principles of microbiology is useful in many lines of work.

D. W. D.

CHEMICAL NOTES

Compiled by the College Department of Chemistry and Soil Science.

Degumming of Anaphe Silk.

The question of the industrial utilisation of Anaphe silk, the product of certain wild silkworms of tropical Africa, has been a subject of enquiry at the Imperial Institute for the past thirty years, and much experimental work has been carried out in the laboratories of the Imperial Institute and in the factories of members of the Imperial Institute Advisory Committee on Silk Production with regard to the preparation of the silk from the raw material and in investigating its possibilities for the silk manufacturing industry. Independently, numerous experiments have been carried out by silk firms in the United Kingdom and on the Continent, especially in Germany. The net result of these investigations is to show that if yarns could be prepared from it as a commercial proposition Anaphe silk would find an outlet in the spun silk trade as a material having a definite value for certain classes of fabric and especially for velvets; while there is good evidence that it would also prove valuable for admixture with wool. The silk is deficient in lustre, but has a pleasing colour (it can if necessary be bleached), and takes dyes well; its strength is satisfactory.

Commercial utilisation depends upon two factors: the cost of production of the degummed silk and yarn, and availability of supplies. Hitherto, the cost of the degummed silk has been excessive as compared with waste silks mainly on account of the relative difficulty of degumming the "nests" and the low proportion of final combed drafts available for spinning into yarns. As regards the "difficulty" of degumming, it has long been evident to the Imperial Institute Committee that if Anaphe silk (raw material) were cheaply available in large quantities satisfactory methods of degumming would rapidly be evolved.

The Anaphe nests which have been considered hitherto in the silk industry are of two main types, viz.:—(i) the *A. infracta* type, in which the colony of cocoons is contained in a tough parchment-like nest more or less globular in shape; and (ii) the type represented by *A. moloneyi*, in which the flat cocoon mass is protected by a comparatively loose silky cover. In the former case the greater part of the silk for industrial purposes is derived from the "parchment" layer while in the second type (as hitherto received in the United Kingdom) the cocoon mass yields most of the silk: the protective covering of this type of nest has usually been removed by weathering or other causes in material so far received in Europe. The morphological differences between the two forms of nests, which are not always recognised, explain the variations met with in the results of degumming and carding experiments with "Anaphe silk".—(*Abstracted from the Bulletin of the Imperial Institute*, Vol. XXX, No. 3.)

The Burning of Cleared Land.

The following is an abstract of a letter by Mr. G. Milne, Soil Chemist to the Amani Research Institute, which appears in *East Africa*, December 29th, 1932:—

The burning of cleared land before cultivating is followed as a superstitious rite in many tropical countries, and the writer feels that there is no experimental evidence for the ruthless condemnation which has been directed at the practice. While it is conceivable that the method is the outcome of blind religious fanaticism, it is also possible that it is the result of accumulated tribal experience and that the disadvantages which are so frequently quoted are counterbalanced by advantages such as are suggested below.

1. The ground is cleared of cumbersome trash, which would later encourage chance fires; upon which fungi, termites, and other doubtful population would thrive; and which, in its unmanageable bulk, would much reduce the effective area for the crop.

2. The addition to the soil of a large quantity of organic matter of low nitrogen-status is prevented. When such material rots in a soil, the whole of that soil's available nitrogen may be for a long time immobilised to further the decomposition, leaving none for the use of a crop in that season.

3. If the localised effects of intense heat under burning logs or close-piled brushwood be excepted, the destruction of humus under a running fire is almost nil. This is well established in the literature of forest and grassland soils, and can be verified by anyone who strolls over the site of a recent "burn" and notes how superficial is the charring of the soil.

4. It may be objected that if humus is not lost, potential humus is. But organic matter is not humus until it is safely metamorphosed into soil colloid. Most of the organic matter in question is in any event destined for complete oxidation—if not by combustion, then biologically, above or below ground.

5. The mineral residues of the brush are retained on the site of cultivation. If you do not burn, you must haul the rubbish aside, and with it its ash-constituents.

6. The reduction in numbers of soil organisms near the surface is at least as likely to have the beneficial effects of a partial sterilisation as harmfully to "destroy the busy bacteria".

7. There is some permanent loss of sulphur and phosphorus in the volatile products of combustion, but the nitrogen-loss so often lamented may, on balance of all processes involved, affect the final nitrogen-economy of the soil very little.

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Market have ranged as follows (c.i.f. per cwt.) :—

	Foreign.	*Preferential.*
	s. d.	*s. d.*
30th Mar. ..	5 11¼	10 8
6th Apr. ..	5 9¾	10 6¾
12th Apr. ..	5 9	10 6
20th Apr. ..	5 7½	10 4¼
27th Apr. ..	5 6	10 3½
4th May ..	5 6	10 3
11th May	5 4½	10 1½
(12*th May*, 1932)..	4 7½	9 4¼

Quiet conditions have prevailed in the Home Market. In New York, however, considerable strength has recently been displayed, which according to *C. Czarnikow, Ltd.*, is attributed to the expectation of important currency developments in U.S.A. and to the growing conviction that some form of inflation would be resorted to in an endeavour to raise commodity values.

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association :—

	American Mid.	*Egyptian F.G.F. Sakel.*
31st Mar. ..	5.15	7.10
7th Apr. ..	5.28	7.27
13th Apr. ..	5.37	7.48
21st Apr. ..	5.30	7.39
28th Apr. ..	5.54	—
5th May ..	5.89	—
12th May ..	6.19	—
(13*th May*, 1932) ..	4.58	6.20

Prices on the whole have shown some little advance partly due to technical reasons and to the belief that the American legislative and other measures will improve the situation. There has been an improved request at steady rates for West Indian Sea Island at 12*d.* to 14*d.*

* * *

COFFEE.—Prices have been maintained and have shown a tendency to rise. Up to 165*s.* per cwt. has been paid for Costa Rica and No. 2 Jamaica Mountain coffee has realised 191*s.*

* * *

BANANAS.—Bananas are in better demand, and the price to wholesalers is £1 per ton higher. Jamaicas are now quoted at £21 5*s.* delivered London and £21 nearest railway station, and Brazilians at £19, nearest station.—(*West India Committee Circular*, April 13th.)

COCOA.—The cocoa situation is in a state of daily change with the value of the American dollar fluctuating. Considerable trading is now being shown by interests, outside of the normal cocoa channels, in anticipation of a general rise in commodity prices in U.S.A. Now that this country has gone off the gold standard, it is currently rumoured that France, Switzerland and the Netherlands will do likewise. The ultimate effect on prices is difficult to anticipate. Meanwhile production is above normal, whilst consumption does not show any increase, the United Kingdom's and Germany's consumption for the months January/February, 1933 being as follows :

	1933.	**1932.**
United Kingdom ..	12,293 tons	14,373 tons
Germany ..	12,831 ,,	19,774 ,,

In London the price of spot Accra is 24*s.* to 24*s.*6*d.* and in Trinidad $5.10 a fanega is being paid. —(*By courtesy of the Cocoa Planters' Association of Trinidad, Ltd.*)

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows :—

	d.
29th Mar.	2 3/32
5th Apr.	2 3/32
12th Apr.	2 9/32
19th Apr.	2 17/32
26th Apr.	2 19/32
3rd May	2¾
10th May	2 13/16
(11*th May*, 1932)	2

After continuing dull for some time the market towards the middle of April showed a distinctly better tone. This, according to *Symington & Wilson* was due to the generally better tone of the commodity market in U.S.A. and to considerable buying of rubber in New York, and to the revival of restriction talk in Holland.

* * *

COPRA.—Copra is considerably lower, and West Indian f.m.s. for May shipment is now quoted at £10 17*s.* 6*d.* *c.i.f.* London or Liverpool. The market has been upset by a margarine restriction scheme in Germany.—(*West India Committee Circular*, April 13th.)

* * *

GRAPEFRUIT.—No Jamaica or Trinidad are on offer and only Florida are available. They are selling at from 24*s.* to 30*s.* according to quality and counts, 80's/126's.—(*West India Committee Circular*, April 13th.)

* * *

LIME PRODUCTS : *Lime Oil.*—There are sellers of Handpressed at 55*s.* but probably less would be accepted. Distilled is nominally unchanged at 35*s.* to 37*s.*, but the continued lack of demand is very disappointing.

Lime Juice.—There is no change to report in Raw, which is quoted at about 2*s.* for good West Indian.—(*West India Committee Circular*, April 13th.)